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NATURAL SCIENCES

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CONTENTS

GENETIC ANALYSIS OF THE QUANTITATIVE MEASUREMENTS OF THE PALM

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The present work deals with the inadequately studied dermatoglyphics of the palm as regards the metrical features between the successive digital triradii. These triradii located at the base of digits II, III, IV and V are designated a, b, c, and d respectively in the radio-ulnar sequences. The ridge counts lying between the digital triradii are called quantitative values of these interdigital areas. Fang (1951) has studied in detail the quantitative value of the second interdigital of the palm. According to him, a pair of allelomorphic genes is responsible for the inheritance of a-b value, and that the allele for 'high' value is dominant over that of low value. There are other studies too on the ridge count (Baitsch and Swartzfischer, 1959; Pons, 1964; Pateria, 1967), but much more attention needs to be further devoted to this area of investigation. No work is available on the genetic analysis of the quantitative value, and hence an attempt is made here to study their nature of distribution from parents to offspring.

The data analysed here in this study represent 150 biological families, comprising in all 480 children out of whom, 295 are male and 185 female. The palms were printed according to the method described by Cummins and Midlo (1961). The prints were examined under a magnifying glass. The digital triradii a, b, c and d were connected by straight lines and the ridges between successive triradii were counted with the help of a sharp needle inserted in a holder. Except interstitial ridges, every line crossing or touching these lines is represented in the count. Here the a-b, b-c and c-d counts of an individual are the combined a-b, b-c and c-d counts of the two palms.

For studying the mechanism of inheritance genetic analysis of ridge count is calculated among persons with varying degrees of relationship.

Table I reveals the distribution of mean ridge count on the hands of male and female parents and their children in the population sample under study. All these distributions are similar for total count in the two sexes. The mean value for a-b ridge count is 74.18 in the male parents and 73.74 in the female parents. It is fairly evident that the mean quantitative value of the offspring lies between the mean values of the parents.

It is apparent from the same table that for b-c ridge count slightly higher mean value is observed among female parents than among males. Sex-wise, the mean value for males is 48.58 and for

TABLE 1

Mean and standard deviation values among parents and children for ridge count a-b, b-c and c-d

		Male Parents	Female Parents	Male Children	Female Children	Inter-digital
		Number 150	Number 150	Number 295	Number 185	areas
Mean		74.18	73.74	71.57	72.84	
	S.E.	±0.97	±0.83	±0.65	±0.83	
						a-b
S.D.		11.95	10.14	11.27	11.37	
	S.E.	±0.69	±0.58	±0.46	±0.59	
Mean		48.58	49.94	48.10	48.05	
	S.E.	±1.02	±0.92	±0.75	±0.82	
S.D.		12.57	11.27	12.90	11.20	
	S.E.	±0.72	±0.65	±0.53	±0.58	
Mean		65.89	67.75	64.22	63.66	
	S.E.	±0.91	±0.91	±0.77	±0.75	
						c-d
S.D.		11.90	11.33	13.31	10.20	
	S.E.	±0.64	±0.65	±0.54	±0.53	

females 49.94. The mean value of male and female children is no more than the male and female parents.

As regards the c-d ridge count, striking difference is observed among male and female parents, where the mean count in females 67.75 is considerably greater than that of male, which is 65.89. Taking this interdigital area into consideration, the trend for male and female children appears to be largely the same as in the case of ridge count a-b and b-c (Table 1).

b-c

As further proof of the genetic basis of quantitative value, the mean ridge count corrected for sex (after Holt, 1952) of parents and offspring could be cited.

It is fairly evident from Table 2 that the mean quantitative value of the offspring lies between the mean values of the parents. The mean ridge count among male and female parents is 75.70 and 76.07 respectively. These values do not differ significantly from the mean value of male and female children even after sex correc-

TABLE 2

Genetic analysis of ridge count a-b

Number	Father	Offspring		Mother
	(Father's mean)*	Son (mean)*	Daughter (mean)*	Mother (mean)*
295	75.70	73.24	—	75.10
185	76.07	—	73.87	75.39
480	75.86			75.06
	73.87			
	Expected intermediate value			
	75.46			
	Difference 1.59			
S.D.	11.33			10.63
S.E.	±0.52			±0.49

* Corrected for sex.

TABLE 3

Genetic analysis of ridge count b-c

Number	Father	Offspring		Mother
	(Father's mean)	Son (mean)*	Daughter (mean)*	Mother (mean)*
295	49.39	48.23	—	49.84
185	48.67	—	48.18	49.53
	48.21			
	Expected intermediate value			
	59.44			
	Difference 1.23			
S.D.	12.60			11.92
S.E.	±0.42			±0.39

* Corrected for sex.

tion. Further more, the difference noticed between observed and expected ridge count values among children is statistically not significant.

It can clearly be seen from the Table 3 that sex-wise distribution of ridge count among male and female parents after sex correction is 49.39 and 48.67 respectively. It is observed that the mean value of male children is 48.23 which does not differ from the mean value of female. However, this value is not more than the parental value. The difference noticed here is not significant. Similarly the observed and expected ridge count value among children do not differ significantly.

TABLE 4

Genetic analysis of ridge count c-d

Number	Father	Offspring		Mother
	(Father's mean)*	Son (mean)*	Daughter (mean)*	Mother (mean)*
295	66.56	65.09	—	68.53
185	66.76	—	64.53	69.27
480	66.66			68.90
	64.81			
	Expected intermediate value			
	67.78			
	Difference 2.97			
S.D.	11.34			11.01
S.E.	±0.37			±0.36

* Corrected for sex.

Table 4 shows the mean total c-d ridge count among parents and offspring. There is no difference observed in the mean value. Here this value as 66.56 in males is quite similar to that of female parents for whom it is 66.76. The offspring do not display more value than their parents. Thus the observed and expected ridge count values are not distinct.

Calculating a mean ridge count corrected for sex between parents and offspring for finger ridge count (Holt, 1952) and Tiwari, 1963) do not exhibit values in close agreement with the mean value of palmar interdigital ridge count. In both these cases it is observed that the mean value corrected for sex of parents and offspring differs significantly. Moreover a distinct difference is noticed between observed and expected ridge count values. As regards the mean value of these interdigital areas, no such trend is observed. The expected and intermediate values do not differ significantly. It may probably be due to the extreme variability of finger ridge count from parents to offspring.

In conclusion the results obtained from these statistical methods show that the quantitative value of palmar interdigital areas has a heritable nature and that the hypothesis of a polymeric system, cannot be discarded.

SUMMARY

Palmar prints of 150 families were obtained to study the nature of distribution of the quantitative value of palmar interdigital areas from parents to their offspring.

For studying the genetic basis of the quantitative value, the mean ridge count corrected for sex has been studied. It is observed that the mean quantitative value of the children lies between the mean values of the parents, and the difference as regards the observed and expected ridge count values is not statistically significant. Thus it can be concluded that the quantitative value of the interdigital areas is under the influence of genes with additive effect.

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A COMPARATIVE STUDY OF THE PALMAR DERMATOGLYPHICS OF JAINS AND MUSLIMS OF SAGAR (MADHYA PRADESH)

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Present study deals with the nature of distribution of various palmar dermatoglyphic features of the Jain and Muslim communities of Sagar town. Hence, it is necessary to know the social structure of these communities.

No data on the physical Anthropology of the Jain and Muslims are available. These two castes are the endogamous group. Intermarriage is strictly prohibited in these communities. The Jains are mainly engaged in business. From the very early times these Jains are called as Vaishyas also and sometime they were known as Banias whose function was to serve the people by different business.

On the basis of various religious evidences it can be said that about 2,500 years ago, Mahavir Swami, who is known as 24th Tirthankar, has laid the foundation of Jain Dharma. Therefore, we can say that there is no definite proof about the origin of Jainism in the country.

The entire Jain community is divided into two sects, the Swetamber and the Digamber. The former wear clothes and the latter remain nacked. The Swetamber have again many exogamous units which are called Choudhari, Modi, Malaiya, Singhai, Baisakhia, Shrimant, etc. The data for studying various palmar dermatoglyphic feature was collected among Swetamber Jains.

Most of the Muslims are here in the town bleonging to a poor class doing the business of Bidi making. Their level of subsistence varies; they are upper class group, landlords, businessmen, a few of them are in service.

The social structure of this community is based on various sects, namely Shia, Sunni, Bohra, etc. On the basis of their occupation they can be categorised into several subcastes. These are Kunjars, who are selling vegetables, Behna are threshing cotton, Rungrej are dyeing the cotton clothes, Mukeri are looking after the cattle and Kasai are engaged in butchering the animals.

The rendomly chosen palmar prints of Kunjra Muslims were collected to study the distribution of palmar dermatoglyphic features and to find out any affinity if any, with the neighbouring population, with this end in view 400 palmar prints of the two caste were collected, representing both the sexes in equal proportion (Table 1).

TABLE 1

Sexwise distribution of the sample

	Jain	Muslim	Total
Male	100	100	200
Female	100	100	200
Total	200	200	400

There is now quite a good deal of literature on the qualitative analysis of various detmatoglyphic features. The important works among these include those by Steggerda and Lane (1936), Biswas (1963), Chakravarti (1963), Tiwari (1963), Sharma and Kalla (1965), Sharma (1968), Bhattarcharya (1964), and Sharma (1962, 1970). These studies prove in ample measure the fact that dermatoglyphic characters display qualitative variations; also that heredity plays an important role in the determination of qualitative dermatoglyphic features.

Table 2 shows the percentage of patterns on various configurational areas of the palm among Jains and Muslims groups. Among Jains the highest frequency of patterns is observed on the hypothenar region (77.50%) which is subsequently decreasing to the thenar I to II and III interdigital area. In Jain females the highest frequency of patterns on palm is observed (65.00%) and for other areas the same trend is observed as in males. Regarding sexual difference a distinct difference is noticed. The Muslim males and females on the other hand, do not differ from the Jains regarding the distribution of patterns on the various configurational areas. The highest frequency, 73.58% and 71.50% among males and female respectively, is observed on the hypothenar areas. This frequency is lowest on III interdigital area among both the cases and again it rises to 45.00% and 44.50% among male & female on IV interdigital areas. Sexual difference is, however, not manifest in the Muslim group. Moreover no ethnic difference is noted.

TABLE 2

Percentage of Palms (Right & Left) of the Two groups showing Patterns on the various Configurational Areas

Configurational Areas	Jains		Muslims		Jains	Muslims	X^2
	Male	Female	Male	Female	M+F	M+F	Value
Hypothenar	77.50	65.00	73.58	71.50	71.25	72.42	0.10
Thenar							
I Interdigital	27.00	25.50	21.50	22.80	26.25	22.15	0.14
II Interdigital	17.00	15.50	20.55	16.45	16.25	18.50	0.07
III Interdigital	30.50	31.00	33.00	32.00	30.75	32.50	0.06
					Result — Not Significant		
IV Interdigital	43.00	41.50	45.00	44.50	42.25	44.75	0.10

Table 3 shows percentage frequencies of the three principal main line formulae. It is found that majority of the individuals of either sex in both the groups shows greater frequency of 11.9.7 formula in the right palm as compared to the left one. Regarding sex difference nothing very distinct is noticed among Jains and Muslims. Similar trend is also observed as regards the 9.7.5 formula.

The frequency of 7.5.5 presents lowest percentage among both these groups. No gereralizations regarding ethnic variation can, however, be made out on the basis of these frequencies.

TABLE 3

Distribution of three palmar formulas among Jain male and female

Palm Formula	Male Right	Male Left	Female Male	Female Female	Male mean	Female mean	X^2 Value	Result
11.9.7	61.29	55.35	61.81	50.94	58.32	56.37		
9.7.5	22.58	21.4.	21.81	28.30	22.00	25.05	0.22	Not Significant
7.5.5	16.12	23.22	16.37	20.75	19.68	18.58		

Distribution of three palmar formulas among Muslims male and female

11.9.7	56.72	51.36	54.50	48.20	54.04	51.35		
9.7.5	20.91	25.90	15.70	16.80	23.40	18.25	4.46	Not Significant
7.5.5	22.87	24.74	29.00	34.80	23.80	31.40		

TABLE 4

Termination of Main Line 'D' among Jains

Mean	Male Left	Male Right	Line D	Female Right	Female Left	Mean
13	2.00	—	1.00	—	1.00	0.50
12	1.00	—	0.50	1.00	—	0.50
11	44.00	44.00	44.00	38.00	38.00	38.00
10	4.00	3.00	3.50	2.00	2.00	2.00
9	30.00	30.00	30.00	32.00	32.00	32.00
8	3.00	—	1.50	2.00	2.00	2.00
7	16.00	23.00	17.50	25.00	25.00	25.00
X	—	—	—	—	—	—

Termination of Main Line 'D' among Muslims

Line D	Male		Mean	Female		Mean
	Right	Left		Right	Left	
13	—	—	—	—	—	—
12	—	—	—	—	—	—
11	56.70	32.21	44.40	51.37	43.05	47.21
10	2.70	2.68	2.69	—	—	—
9	17.50	25.51	22.50	15.75	18.05	18.90
8	0.67	0.76	0.71	—	—	—
7	24.32	38.92	31.62	32.87	38.89	35.88
X	—	—	—	—	—	—

TABLE 5

Termination of Main Line C among Jains

Line C	Male		Mean	Female		Mean
	Right	Left		Right	Left	
11	10.00	6.00	8.00	7.00	—	3.50
10	4.00	2.00	3.00	6.00	5.00	5.50
9	52.00	48.00	50.00	48.00	50.00	49.00
7	18.00	23.00	20.50	20.00	19.00	19.50
6	—	2 00	1.00	1.00	3.00	2.00
5'	6.00	8.00	7.00	6.00	4.00	5.00
5"	3.00	1.00	2.00	5.00	4.00	4.50
X	7.00	10.00	8.50	7.00	15.00	11.00

Termination of Main Line C among Muslims

11	1.31	—	0.65	2.79	—	1.39
10	3.45	—	1.72	2.20	—	1.10
9	53.57	46.61	50.90	53.15	49.65	56.40
7	18.62	29.16	23.89	15.38	20.57	17.97
5	12.39	20.14	16.26	26.48	29.08	27.78
5	—	2.19	1.95	—	0.70	0.35
X	—	—	—	—	—	—

TABLE 6

Termination of Main Line B among Jains

Line B	Male		Mean	Female		Mean
	Right	Left		Right	Left	
9	5.00	6.00	5.50	7.00	4.00	5.50
8	12.00	12.00	12.00	8.00	6.00	7.00
7	8.00	4.00	6.00	4.00	5.00	4.50
6	31.00	30.00	30.50	31.00	40.00	35.50
5"	31.00	25.00	28.00	27.00	22.00	24.50
5'	8.00	18.00	13.00	14.00	19.00	16.50
4	1.00	—	0.50	—	3.00	1.50
X	4.00	5.00	4.50	.00	1.00	5.00

Termination of Main Line B among Muslims

9	4.79	—	2.39	4.13	—	2.65
8	3.42	—	1.71	1.37	—	0.68
7	54.11	34.93	44.57	49.99	46.13	48.60
6	—	—	—	—	—	—
5"	—	2.73	1.36	—	0.54	0.27
5'	34.25	58.21	46.33	41.10	50.34	45.72
4	3.43	—	1.71	—	—	—
X	—	—	—	—	—	—

From Tables 4 to 7, it is apparent that the most frequent endings of main lines D are at position 11.9.7 in order of preponderance. Main line C ends in order of preponderance at position 9.7.5, while Main line B ends at position 5 to 6 and among Muslims at position 5 to 7. Line A at positions 4, 5, 3, 1. The maximum frequencies of these main lines in both the sexes do not present any marked different. Similar position is also observed as regards the ethnic variation.

Table 8 shows the distribution of main line index in the populations under study. It is found that majority of individuals of iteher sex in both the groups have highest frequency of main line index in their right hands as compared to the left one. These main line indices are remarkably similar in both the sexes and also in both the groups.

The frequency for various types of axial triradii does not very significantly

TABLE 7

Termination of Main Line A among Jains

Line A	Male		Mean	Female		Mean
	Right	Left		Right	Left	
11	1.00	2.00	1.50	3.00	2.00	2.50
9	—	—	—	1.00	—	0.50
7	4.00	3.00	3.50	2.00	1.00	1.50
6	2.00	2.00	2.00	1.00	3.00	2.00
5"	10.00	15.00	12.50	14.00	17.00	15.50
5'	25.00	18.00	21.50	27.00	20.00	23.00
4	50.00	28.00	29.00	32.00	28.00	30.00
3	24.00	27.00	25.50	17.00	25.00	21.00
2	4.00	5.00	4.50	3.00	—	3.50
1	—	—	—	—	—	—
X	—	—	—	—	—	—

TABLE 7

Termination of Main Line A among Muslims

Line A	Male		Mean	Female		Mean
	Right	Left		Right	Left	
11	—	—	—	—	—	—
9	—	—	—	—	—	—
7	—	—	—	—	—	—
5"	19.72	6.75	10.23	9.64	7.81	8.72
5	10.50	4.73	7.64	19.32	13.79	16.50
5'	4.22	—	2.11	7.81	1.37	4.62
4	27.47	22.75	25.11	30.35	20.33	25.34
3	26.75	36.26	31.50	18.62	17.92	18.27
2	7.04	18.24	12.64	14.48	27.58	21.03
1	—	—	—	—	—	—
X	4.21	11.48	7.84	4.82	13.20	9.01

TABLE 8

Distribution of Main-Line Index among Jain and Muslim

Ethnic Group	Male		Mean (Right+Left)	Female		Mean (Right+Left)
	Right	Left		Right	Left	
Jain	8.95	8.32	8.63	8.35	7.94	8.14
Muslim	8.14	7.39	7.76	9.15	8.22	8.63

TABLE 9-A

Percentage distribution of axial triradii among Jain and Muslim

Axial triradii	Male		Result X^2 Value		Female		Result X^2 Value	
	Right	Left			Right	Left		
t	61.00	58.00			58.00	57.00		
t'	25.00	30.00			18.00	26.00		
t''	8.00	5.00	3.77	Not significant	10.00	12.00	3.25	No significa
tt'	3.00	4.00			2.00	2.00		
tt''	3.00	2.00			1.00	2.00		
t' t''	2.00	1.00			1.00	1.00		

TABLE 9-B

Bisexual difference as regards the distribution of axial triradii among Jain male & female

Male Mean (Right+Left)	Female Mean (Right+Left)	X^2 Value	Result
59.50	57.50		
27.50	22.00		
6.50	11.00	3.29	Not significant
3.50	2.00		
2.50	1.50		
1.50	1.00		

TABLE 9-C

Percentage distribution of axial triradii among Muslim male and female

Axial triradii	Male		X^2 Value	Result	Female		X^2 Value	Result
	Right	Left			Right	Left		
t	95.39	92.00			97.34	96.00		
t'	4.00	7.34	1.03	Not significant	2.66	3.34	0.41	Not significant
t"	0.61	0.66			0.00	0.66		

TABLE 9-D

ixexual difference as regards the distribution of axial triradii among Muslim male & female

Male Mean (Right+Left)	Female Mean (Right+Left)	X^2 Value	Result
93.66	96.66		
5.66	2.99	1.21	Not significant
0.66	0.33		

between Jain and Muslim samples. Sex-wise difference among Jain is not statistically significant. Among Muslim insignificant bisexual difference is observed (Table 9).

It is also noted here that the frequency of triradius : t is highest in both the sexes and also in both the groups. The right palm presents higher frequency for triradius t as compared to left. A reversal of this trend is, however, noticed in case of t and t".

On the basis of observations made above, it can, therefore, be concluded that ethnisally no difference is obtained between Jain and Muslim on the basis of palmar dermatoglyphic features.

SUMMARY

Randomly chosen palmar prints of 400 Jains and Muslim individuals were obtained to study the nature of distribution of the various palmar dermatoglyphic features.

These two groups are two different ethnic stain. They are genetically isolated from a long period. We may therefore expected a distinct ethinic difference in two caste group under study. However no such difference is observed.

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PALMAR DERMATOGLYPHICS AMONG CONGENITAL DEAF PATIENTS

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Palmar prints of congenital deaf patients of both sexes (male 156 and female 38) have been collected from Bangalore Deaf Training School. The control population consists of 536 male and 234 females. Evaluative palmar dermatoglyphics have been reported which include main line formulae, C-line polymorphism, axial triradii and palmar pattern areas. C-line polymorphism and axial triradii in male patients are significant from its control population.

INTRODUCTION

The congenital deafness is caused by intra-uterine factors (Urbantschitsch et al., 1910). The discoveries of Gregg (1941) and of Australian workers indicate that rubella in the mother in the early weeks of pregnancy could cause deafness or other congenital defects in her child. There is no firm evidence that any other known virus does in fact cause such congenital factors.

Since 1967, dermatoglyphic features with congenital deafness attracted geneticists. Turpinetal (1967) reported that familial deafmutes showed a slightly raised frequency of high axial triradius and total hypothenar patterns in their palmar dermatoglyphics. Dar and S. T. Winter (1970) made study of 239 patients with familial deafness who showed high frequency of simian crease. According to them, it does not show clear relationship between deafness and forms of simian crease. Neelam Sharma (1975) found increase in incidence of whorls, significant 't' index, higher main line index and appreciable increase in the occurrence of termination of line C.

MATERIAL AND METHOD

The data have been collected from Deaf Training School of Bangalore. The data consists of 156 male and 38 female patients with 536 male and 234 female normal controls of the same stock. Care has been taken to include unrelated subjects. The data have been analysed according to the methods of Cummins and Midlo (1961) and C-line types that of plato (1970).

The present study deals with qualitative palmar dermatoglyphics, viz. main line formulae, C-line polymorphism, axial triradii, hypothenar and interdigital areas patterns.

Statistical comparisons were carried out through Chi-square test and contingency of association.

DISCUSSION

Table 1 (a) shows main line formulae of patients and control group. The differences between various main formulae are not statistically significant both in male and female patients. (Male patients : MC Vs. MP, x^2 = 5.83, df_3, 0.10 > P > 0.05, N.S.C. = 0.064;
Female patients :
FC Vs. FP, x^2 = 2.24, df_3, 0.70 > P > 0.50, N.S.C. = 0.0640).

Table 1(b) shows C-line polymorphism of patients and control group. The differences in C-line polymorphism in male patients are statistically significant while in female patients they are not significant (MC Vs. MP, x^2= 13.34, df_3, 0.01 > P > 0.001, S.C. = 0.0974.
FC Vs. FP, x^2 = 1.1, df_3, 0.80 > P > 0.70, N.S.C. = 0.0447).

Table 1 (C) shows axial triradii of patients and control group. The differences between various types of axial triradii in male patients are statistically significant while in female patients it is not significant (MC Vs. MP, x^2 = 6.31, df_2, 0.02 > P > 0.001, S.C. = 0.067.
FC Vs. FP, x^2 = 0,41, df_2, 0.90 >P> 0.80, N.S.C. = 0.0264).

Table 1(d) shows presence of patterns on palmar areas of patients and control group. The differences for various pattern areas are not statistically significant both in male and female patients —

MC Vs. MP, x^2 = 1.23, df_4, 0.90 > P > 0.80, N.S.C. = 0,0223.

FC Vs. FP, x^2 = 2.11, df_4, 0.80 > P > 0.70, N.S.C. = 0.0479.

TABLE 1 (a)

Showing main line formulae of con. deaf patients

M.L.F.	MALE CONTROL		MALE PATIENT		FEMALE CONTROL		FEMALE PATIENT	
11.9.7	358	(33.40)	97	(31.08)	153	(32.68)	27	(35.52)
9.7.5.	139	(12.96)	29	(9.29)	65	(13.88)	10	(13.15)
7.5.5	168	(15.67)	39	(12.50)	80	(17.09)	8	(10.52)
Others	407	(37.96)	147	(47.11)	170	(36.32)	31	(40.78)

MC Vs. MP, x^2 = 5.83, df_3, 0.10 > P > 0.05, N.S.C. = 0.064;
FC Vs. FP, x^2 = 2.24, df_3, 0.70 > P > 0.50, N.S.C. = 0.0640).

Note : MC = Male control; N.S. = Non-significant; S = Significant; C = Contingency of association; FC = Female control; FP = Female patient; MP = Male patient Figures in the brackets indicate percentage.

TABLE 1 (b)

Showing C-line polymorphism of con. deaf patients

C-line	MALE				FEMALE			
	CONTROL		PATIENT		CONTROL		PATIENT	
C-Ulnar	389	(36.27)	94	(30.12)	183	(39.10)	26	(34.20)
C-Radial	513	(47.85)	145	(46.47)	204	(43.59)	38	(50.00)
C-Proximal	113	(10.54)	41	(13.14)	56	(11.96)	8	(10.52)
C-Absent	57	(5.31)	32	(10.25)	25	(5.34)	4	(5.26)

MC Vs. MP, $x^2 = 13.34$, df_3, $0.01 > P > 0.001$, S.C. = 0.0974.
FC Vs. FP, $x^2 = 1.1$, df_3, $0.80 > P > 0.70$, N.S.C. = 0.0447.

TABLE 1 (c)

Showing axial triradii of con. deaf patients

	MALE				FEMALE			
	CONTROL		PATIENT		CONTROL		PATIENT	
Proximal	789	(73.59)	213	(68.26)	337	(72.00)	52	(68.42)
Distal	161	(15.01)	47	(15.06)	69	(14.74)	13	(17.10)
Multiple	122	(11.38)	52	(16.66)	62	(13.24)	11	(14.46)

MC Vs. MP, $x^2 = 6.31$, df_2, $0.02 > P > 0.001$, S.C. = 0.067.
FC Vs. FP, $x^2 = 0.41$, df_2, $0.90 > P > 0.80$, N.S.C. = 0.0264.

Simian lines, its transitional lines and sydney lines are not significantly different both in male and female patients.

CONCLUSION

Various qualitative palmar dermatoglyphics of congenital deaf male and female patients have been discussed. The results are as follows :

(1) Main line formulae are not significant in both male and female patients.

(2) C-line polymorphism is significant only in male patients but not in female patients.

TABLE 1 (d)

Showing presence of patterns on palmar areas of con. deaf patients

Palmar Area	MALE				FEMALE			
	CONTROL		PATIENT		CONTROL		PATIENT	
Hypothenar	292	(27.23)	92	(29.48)	163	(34.82)	32	(42.10)
Thenar/Ist Int.	135	(12.59)	45	(14.42)	52	(11.11)	12	(15.78)
II Interdigital	95	(8.85)	29	(9.30)	26	(5.55)	8	(10.52)
III Interdigital	527	(49.16)	163	(42.24)	218	(46.58)	40	(52.64)
IV Interdigital	614	(57.27)	172	(55.12)	283	(60.47)	47	(61.84)

MC Vs. MP, $x^2 = 1.23$, df_4, $0.90 > P > 0.80$, N.S.C. = 0,0223.
FC Vs. FP, $x^2 = 2.11$, df_4, $0.80 > P > 0.70$, N.S.C. = 0.0479.

(3) Axial triradii are significant only in male patients but not in female patients.

(4) Palmar pattern areas among male and female patients are not significant.

Simian lines, transitional lines and sydney lines are not significant.

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STUDIES OF FOOT ROT AND LEAF ROT OF PIPER BETLE V. CONTROL OF FOOT ROT DISEASE BY FLOOD FALLOWING AND SUNBAKING OF SOIL

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INTRODUCTION

Foot rot of *Piper betle L.* is caused by the pathogen *Phytophthora parasitica* Dast. var. *piperina* Dast. and is responsible for serious damage to the betel vine crop at Sagar, and in fact in all the betel vine cultivation areas in the country. Tiwari and Mehrotra 1968, 1974; Tiwari, 1970, 1973; Saksena and Mehrotra 1970; Mehrotra and Tiwari 1971 studied the saprophytic survival, factors incluencing the growth and sporulation of the pathogen, the recurrence of the disease, and biological control.

While it may be possible to 'starve out' a pathogen by withholding its host, more drastic manipulations of the environment such as flood fallowing usually appear necessary to destroy the resting structures. Moore (1949) advocated flooding for killing sclerotia of *Sclerotinia sclerotiorum* Fuckel. Stover (1954, 1955, 1956, 1958a, 1958b, 1962) recommended flood fallowing which causes a great reduction in the pathogen & changes in the soil microflora similar to that in soil fumigation. Flood fallowing to the pathogen has direct or indirect effect of the microbial activity of the pathogen (Sewell 1965). Heat treatment is one of the oldest methods for eradicating the pathogens from soil. Efforts were, therefore, made to control foot rot by first saturating the soil with water for a few days and then exposing it to the direct sun after tilling.

MATERIAL AND METHODS

The experiment was performed under field conditions in the month of April—May when the temperature goes upto 40-42°C. These months were also suitable from the point of view of betel vine cultivation when normally initial land operations for plantation are taken in hand by the cultivators.

Two plots of 3.5 x 3.5 meters situated about 6 meters away from one another were prepared in the University Botanical Gardens by bringing soil from a local betel vine orchard where severe foot rot disease was observed during the rainy season. Infected host pieces and sand-oatmeal inoculum that had formed a large number of chlamydospores were mixed in both the plots. Adequate moisture was maintained to assure good condition of the pathogen in the soil by irrigation. One of the plots was covered properly from all the sides to

simulate a small orchard and was watered regularly. The other plot was flooded with water for 10 days and later allowed to dry to a stage till tilling could be done smoothly. The soil was then turned up side down with a shovel upto 13 cm. deep and exposed to sun for 15 days. Tilling was repeated once within this duration. After 15 days, when the soil became completely dry, this plot was also covered from all the sides and a small orchard was raised. In both the plots healthy established cuttings of betel vine were planted in the normal manner. In one row of the first plot (untreated), the cuttings were dipped in spore and mycelial suspension of *Trichoderma viride* Pers ex Fries (an isolate from rhizosphere of *P. betel)* before plantation. Soil samples from both the plots at different locations were taken by inserting the mouth of sterilized wide mouthed bottles upto 4 cm. depths and plated for microbial counts by dilution plate method. Presence of *Phytophthora* was determined by the method of Ocana and Tsao, 1965. Both the plots were closely observed for disease incidence and scored for percentage infection (Mitra 1931). The plots were watered regularly to keep the moisture at the same level of betel vine orchards.

RESULTS, DISCUSSION & CONCLUSION

The observations on the combined effect of waterlogging and sunbaking of the soil on control of foot rot disease and the absolute number of bacteria, actinomycetes and fungi are presented in Table I. Fungi occurring in the treated and untreated plots are presented in Table II.

It was found that the disease did not appear till the rains which started in late June. Disease intensity increased in the untreated plot, most of the plants were sick or dead except in the row where cuttings dipped in the spore and mycelial suspension of *T. viride* were sown. In the treated plot only 21% infection occurred as compared to untreated plot where infection was 65%. No *Phytophthora* could be isolated from this plot by Ocana and Tsao's method. The microbial population was also altered: the number of bacteria and fungi increased but that of actinomycetes decreased (Table I). A perusal of Table II indicates that after the treatment several fungal species were eliminated whereas more resisting forms dominated the population. Among these *T. viride* and *Aspergillus niger* Van Tiegham were abundantly

TABLE I

Percentage infection by P. parasitica var. piperina and absolute number of different kinds of microorganisms in the soil treated by flood fallowing and sun baking.

	Percentage Infection	Number of microorganisms in 1 x 10^6/qm.		
		Bacteria	Actinomycetes	Fungi
Plot I (Untreated)	65.0	47.0	1.97	0.013
Plot II (Treated)	21.60	61.0	1.12	0.020

present in the treated soil, followed by *Aspergillus terreus* Thom, *F. oxysporum* and a black sclerotial form.

From the above results it appears that at least three factors played important role in the suppression of foot rot disease : (i) Waterlogging which initiated germination of resting propagules like chlamydospores and created anaerobic condition in the soil environment which was deterimental to the pathogen and other microorganisms, (ii) sunbaking which killed the germ tubes and hypae of the pathogen to a great extent, and (iii) antogonism by surviving soil saprophytes such as *T. viride, A. terreus* and others. Thus all these factors acted in a cumulative manner. This metod of control has an advantage as waterlogging and sunbaking the soil are simple procedures which can be easily followed by the cultivators.

TABLE II

Incidence of different species of fungi in untreated and treated soils of plot I and II

Species of fungi	Plot I	Plot II	
		Before treatment	After treatment
Aspergillus terreus Str. I	++	++	+++
A. terreus Str. II.	+	—	—
A. niger	+++	++	++
A. fumigatus	++	+++	—
A. nidulans	+	+	+
Chaetomium venesuelense	+	+	++
Curvularia lunata	+	+	—
Fusarium solani	+	+	—
F. oxysporum	++	++	+++
F. dimerum	++	++	—
F. culmorum	+	+	—
Pencillium sp.	+	+	—
P. nigricans	++	++	—
Paecilomyces fusisporum	+	+	—
Stachybotrys atra	+	++	—
Sterile black form	++	++	++++
Rhizopus nigricans	++	++	++
Trichoderma viride	+	+	++++
White sterile form	+	+	—

Ratings — = Absent; + = Sporadic; ++ = Moderate; +++ = Good; ++++ = Abundant.

SUMMARY

Combined effect of flood fallowing and sunbaking of soil on control of foot rot disease of *P. betel* caused by **P. parasitica** var. *piperina* has been studied under field conditions. In the treated plot, disease control was obtained to an appreciable degree as only 21.6% infection occurred. The number of bacteria and fungi increased. More resisting and anagonistic forms dominated the population whereas others were eliminated.

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TAXIMETRIC ANALYSIS OF *TEPHROSIA* PERS. SPECIES

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ABSTRACT

Six species of *Tephrosia* are considered for taximetric analysis to interprete thier taxonomic status. For the comparison of morphological characters KMRT analysis was performed. Percent similarities between these taxa based on these morphological characters were calculated. Similarity matrix and phenogram was constructed to show the level of similarity and taxonomic distances between the considered species of *Tephrosia*.

INTRODUCTION

Taximetric studies are the modern approaches in interpreting phyletic similarities and dissimilarities of the taxa. The basic idea of the taximetric analyses lies in the fact that many characters can be studied at a time. On the basis of these results taxa can be rearranged in the existing system of classification. The conventional taxa in this study are considered as OTU's (Sokal and Sneath, 1963). Numerical approach to flowering plants has been successfully applied by Watson *et. al.* (1967) and Prance *et. al.* (1969).

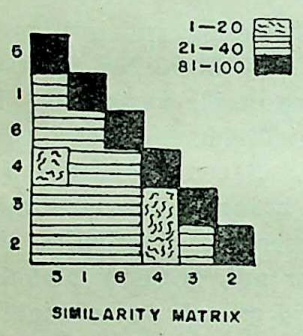
Looking towards the recent trends in systematics it was decided to use taximetrics in interpreting taxonomic status of six species of *Tephrosia*.

MATERIAL & METHODS

Plant material of all the species under study was collected. The collections were done in flowering and fruiting seasons and from different localities to consider maximum intraspecific variations. Nearly one hundred individuals of each species were collected. Seven qualitative (Presence of hairs on branches, leaves simple or compound, presence of stipules, inflorescence raceme or not, presence of hairs on pod, pod turgid or not, pod straight or curved) and twelve quantitative (leaf length, leaf breadth, stipule length, internodal length, pedicel length, flower size, sepal length, petal length, filament length, pistil length, pod length and number of seeds per pod) morphological characters were studied. OTU's considered in this investigation are: 1 *Tephrosia purpurea* 2. *T. strigosa* 3. *T. pumila* 4. *T. candida* 5 *T. villosa* 6. *T. grandiflora*. The measurements of quantitative characters were recorded and the mean, standard deviation and standard error of the mean were calculated for each character in individual OTU's. After computing these statistical attributes Keul's multiple range test (Woolf, 1968) was per-

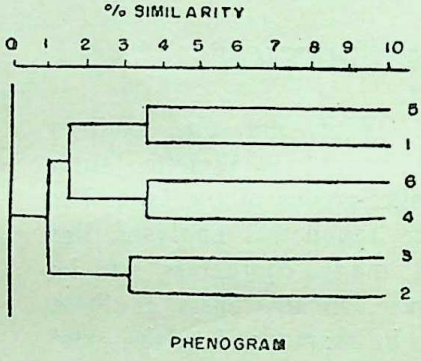
formed. By this method one can compare a large number of means simultaneously. Results of KMRT analyses are given in Table I. In this table means which are over a given continuous line do not differ significantly from each other while those over different lines differ significantly. The percent of similarity based on these characters was calculated. A similarity matrix (Sokal and Sneath, 1963) was constructed for the taxa on the basis of percent similarity. Phenogram (Sokal, 1966) was constructed from matrix to show the level of similarity and taxonomic distances between the OUT's.

percent similarity by which the species of *Tephrosia* were observed to be related together was comparatively low showing there by great dissimilarity between them. Clustering of *T. villosa* and *T. purpurea* together may be justified as both of them belong to subgenus Reineria *T. candida* and *T. grandiflora* belong to other subgenus and hence they appeared as a separate cluster. *Tephrosia purpurea* and *T. pumila* differed markedly from each other and it appears that *T. pumila* should be considered as a distinct species (as is done by Duthie, 1960) and not as a variety of *T. purpurea* (according to Hooker,



SIMILARITY MATRIX

FIG. 1



PHENOGRAM

FIG. 2

SIMILARITY MATRIX AND PHENOGRAM SHOWING RELATIONSHIPS AMONG TEPHROSIA SPECIES

DISCUSSION

An examination of similarity matrix and phenogram (Fig. 1 and 2) reveals the existence of two subgroups in *Tephrosia* species under study. *T. villosa* (OTU 5), *T. purpurea* (OTU 1) and *T. grandiflora* (OTU 6) and *T. candida* (OTU 4) paired at 36% similarity level; while *T. pumila* (OTU 3) and *T. strigosa* (OTU 2) grouped together at 31% similarity level. The

1879). However, these two taxa differed markedly in their gross morphology and the statistical differentiation obtained in the present study supported it.

ACKNOWLEDGEMENT

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TABLE I

Results of KMRT analysis for **Tephrosia**

Qualitative characters —

1. Presence of hairs on branches

Taxon No.	1	2	4	6	3	5

2. Leaves simple or compound

Taxon No.	2	1	3	4	5	6

3. Presence of stipules

Taxon No.	1	2	3	5	6	4

4. Inflorescence raceme of not

Taxon No.	1	4	5	6	2	3

5. Presence of hairs on pod

Taxon No.	1	4	5	2	3	6

6. Pod turgid or not

Taxon No.	1	3	5	2	4	6

7. Pod straight or curved

Taxon No.	1	2	5	6	3	4

Quantitative characters —

8. Leaf length

Taxon No.	5	1	3	6	2	4
Mean	1.1	1.6	1.7	1.7	2.1	4.2
S.E.	0.1	0.04	0.0	0.14	0.1	0.3

9. Leaf breadth

Taxon No.	2	6	5	3	1	4
Mean	0.3	0.3	0.5	0.6	1.0	1.1
S.E.	0.0	0.0	0.05	0.01	0.02	0.07

10. Stipule length

Taxon No.	4	2	3	5	1	6
Mean	0.0	0.1	0.1	0.4	0.5	1.0
S.E.	0.0	0.0	0.0	0.0	0.0	0.0

11. Internodal length

Taxon No.	2	6	5	1	3	4
Mean	1.8	2.1	2.7	3.3	3.9	5.5
S.E.	0.09	0.7	0.1	0.07	0.1	0.13

12. Pedicel length

Taxon No.	3	5	1	2	6	4
Mean	0.2	0.3	0.5	0.6	0.7	1.0
S.E.	0.0	0.02	0.0	0.02	0.0	0.03

13. Flower size

Taxon No.	2	3	5	1	4	6
Mean	0.3	0.5	0.7	0.8	1.7	1.8
S.E.	0.0	0.0	0.02	0.0	0.02	0.02

14. Sepal length

Taxon No.	2	3	4	6	1	5
Mean	0.1	0.2	0.4	0.4	0.5	0.5
S.E.	0.0	0.0	0.0	0.0	0.0	0.0

15. Petal length

Taxon No.	2	3	5	1	4	6
Mean	0.3	0.3	0.6	0.8	1.7	1.7
S.E.	0.0	0.0	0.0	0.0	0.0	0.0

16. Filament length

Taxon No.	2	3	5	1	4	6
Mean	0.2	0.3	0.6	0.7	1.7	1.7
S.E.	0.0	0.0	0.0	0.0	0.0	0.0

17. Pistil length

Taxon No.	2	3	5	1	4	6
Mean	0.2	0.4	0.7	1.0	1.8	1.8
S.E.	0.0	0.0	0.0	0.0	0.0	0.0

18 Pod length

Taxon No.	2	5	3	1	6	4
Mean	1.4	2.7	3.3	3.4	5.6	7.6
S.E.	0.02	0.1	0.02	0.0	0.16	0.34

19. Number of seeds

Taxon No.	1	2	3	5	6	4
Mean	6	6	6	6	9	11
S.E.	0.0	0.0	0.0	0.0	0.3	0.4

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STUDIES ON COPROPHILOUS ASCOMYCETES III. EFFECT OF VARIOUS TEMPERATURE AND THE HEAT RESISTANCE ON ASCOSPORE GERMINATION

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INTRODUCTION

The mechanism involved in the germination of fungus spore presents a problem of a considerable mycological importance. In many fungi, the condition required for germination of spores may be different from species to species. There are several cases where the cardinal temperature for the germination of different type of spores of the same organism may differ, as in some of the uredinales (Doran 1922, Arthur 1929 and Cochrane 1945). It is known that ascospores of some ascomycetes require a heat shock in order to germinate and are very resistance to extremes of temperature (Faull 1930, Lingappa and Sussman 1959). Celerin and Fergus (1971) studied the effect of nutrition and temperature on the ascospores germination of thermophilous chaetomia. The experiments in this study were designated to test certain phases of germination, including temperature relation and thermoduricity of ascospores of three coprophilous chaetomia.

MATERIAL & METHODS

The organisms studied here were isolated from various types of dung and described as coprophilic. Three species of *Chaetomium*, viz., *C. indicum*, *C. bostrychodes* and *C. robustum* were studied. Ascospores were obtained by incubating test fungi on PDA slants for 15 days at 28°C.

Preparation of ascospore suspension :

Spore suspension was prepared by harvesting and crushing 8—10 perithecia in a culture tube having 5 ml of sterile distilled water. The culture tube was shaken well with the help of mechanical shaker to dislodge the ascospores from crushed perithecia. The resultant spore suspension was taken in an empty sterile centrifuge tube, the tube was centrifuged for 2 minutes at 3,000 rpm. The supernatant was discarded, more sterile distilled water was added and suspension again centrifuged. Thus, mycelial bits or perithecial fragments were removed. The ascospores settled down in the tube were used in the further studies. Ascospore suspension of all the test species of *Chaetomium* was prepared by the same technique.

The ascospore suspension was pipetted on 8 mm discs of dung agar (D.A.) medium. These discs were incubated at various temperatures, i.e. 15, 25, 28, 30, 35, 40 and 45°C. Spore germination was re-

corded after 24 hours incubation. Influence of high temperature was studied by exposing the ascospore suspension in a constant temperature water bath then germinated on D.A. Spore suspension of *Chaetomium* species were taken in thin walled glass tube. A thermometer was placed in the glass tube having spore suspension and then the tube was placed in water bath. As soon as the spore suspension attained the desired temperature, timing was commenced. The thermal death range and thermal death point were determined by exposing ascospores to 40, 50, 60 and 70°C for 2, 5, 10 and 15 minutes. Drops of ascospore suspension from each tube were placed on D.A. disc and incubated at 28°C for 24 hours. Care was taken to maintain humidity inside the dishes in which the discs containing ascospores were kept in order to insure that the medium do not dry up during the course of experiments. Spore germination was recorded after 24 hours incubation by counting the germinated and non-germinated spores of a disc. About 100 ascospores were counted on each D.A. block and number germinated was expressed as percentage of these.

RESULTS & DISCUSSION

Mature ascospores of all the three species of *Chaetomium* are olivaceous and ellipsoid, possessing a single germ pore. The spore germination starts by extruding small, hyaline globose vesicle through the germ pore. After this one or two germ tubes develop from the vesicle, which may be branched in some spores, while in some spores germ tube elongate considerably before branching. No remarkable swelling of the ascospores during the phase of germination was observed in any of the *Chaetomium* species under test, and thus resemble the ascospore germination of *Chaetomium* and *Sordaria* as reported by Page (1939) and Butler (1956).

Poor germination was noted (Table I) at 25°C, whereas germination was found to be zero below this temperature, i.e. 15°C. A perusal of the data showed a gradual increase in the percentage germination of all the test species by increasing the temperature upto 30°C.

Maximum germination of ascospores was 67, 70 and 72 per cent for *C. indicum*, *C. bostrychodes* and *C. robustum* respectively at 30°C temperature. Above this temperature inhibition in ascospore germination was noted. No germination was seen at 40°C and 45°C. For all the *Chaetomium* species 30°C seems to be the optimum for ascospore germination. The minimum temperature for ascospore germination must fall between 15 and 25°C, and maximum between 30 and 35°C. Since the highest percentage of ascospore germination was noted at 30°C and a tremendous reduction in ascospore germination was obtained at 35 and 40°C.

Interrupted heat treatments :

The ascospores require different time periods at different temperatures for germination. Germination was fast in all the species of *Chaetomium* when activated at 40°C for 2 minutes. *C. indicum* showed 48 per cent germination at this temperature when exposed for 5 minutes. A gradual decrease in germination was noted by increasing the temperature above 40°C and also increasing the time of activation

(Table — II). Germination was affected at 50, 60 and 70°C even after a very short (2 min.) period of heat activation. The ascospores of *C. indicum* could not survive when exposed for 15 minutes at 40°C and 50°C. No germination occurred at 60 and 70°C even after the treatment for 5 min.

The temperature maxima for ascospore germination of *C. bostrychodes* was 70°C, germination itself was affected and only 38 per cent germination was noted after activating the spores for 2 min. The ascospores of this fungus can resist the exposure of 10 min. at 50°C. Increase in the activation period inhibit the cent percent spore germination at this temperature. Ascospores of *C. robustum* were found to be more susceptible to heat. Spore germination was more than 52 per cent after activation at 40°C for 2 min. At this temperature if the time of exposure was increased, i.e., for 15 min., not even a single spore could germinate. On the other hand, no germination occurred at 60 and 70°C even after a exposure for two minutes. The ascospores of this species can not tolerate high temperature (50°C) for more than 10 min.

These observations confirm the heat resistance of ascospores of *C. indicum* and *C. bostrychodes* upto 70°C and can be designated as thermotolerant but their thermo-duricity was found to be very less. Dickson (1932) reported that very few ascospores of *Chaetomium cochliodes* could survive 2 min. exposure to 80°C. Warcup and Backer (1963) found that ascospores of *Chaetomium* species in soil could not survive 30 min. at 60°C. Fergus (1954) reported 10 min. exposure to 42 to 44°C killed the ascospores of *Ceratocystis fagacearum*. Heat resistance of ascospores of *Neurospora crassa* was studied by Faull (1930), who reported that they survive for more than 4 hours at 50°C. Ascospores of *C. robustum* were much more susceptible to injury by high temperatures.

The spores that survive in a long exposure to a high temperature require a long time to germinate (Faull 1930, Celerin and Fergus 1971). The germinability and survivability of ascospores of *C. indicum* and *C. bostrychodes* at a temperature of 50°C is of a considerable significance for coprophilic species. The spore germination of many coprophilous fungi will take place only if they receive short high temperature

TABLE I

Percentage ascospore germination of *Chaetomium* spp. at various temperatures.

Organisms	Percent germination after 24 hrs. incubation						
	15°C	25°C	28°C	30°C	35°C	40°C	45°C
Chaetomium indicum	0	42	58	67	48	0	0
C. bostrychodes	0	36	68	70	56	0	0
C. robustum	0	40	66	72	60	0	0

TABLE II

Germination (%) of ascospores on dung agar medium following exposure to various temperatures and times.

Organisms	40°C EXPOSURE TIME IN MINUTES				50°C EXPOSURE TIME IN MINUTES				60°C EXPOSURE TIME IN MINUTES				70°C EXPOSURE TIME IN MINUTES			
	2	5	10	15	2	5	10	15	2	5	10	15	2	5	10	15
C. indicum	47	48	20	0	38	32	22	0	28	0	0	0	26	0	0	0
C. bostrychodes	58	54	32	0	52	40	20	0	48	0	0	0	38	0	0	0
C. robustum	52	46	28	0	42	30	12	0	0	0	0	0	0	0	0	0

treatments (Fries, 1956). They do not get injured or damaged during the process of digestion. In fact the intestine temperature and the various digestive juice break their dormancy (Ingold 1953) and stimulate them to germinate readily on the dung.

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KERATINOPHILIC FUNGI FROM THE SOILS OF SAGAR (M.P.)

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INTRODUCTION

Following the death of the animals or insects the remains are added to the soil. A lot of substrate rich in keratin may also be added in soil in the form of feathers, hair, nails, wool etc. These are then subjected to successive and overlapping waves of colonisation by the soil inhabiting micro-organisms. The soil saprophytes are specialised in their mode of action on a particular type of substrate. The primary colonisers show a sudden flare-up into activity on the newly added substrates and utilise mainly the easily available simple carbohydrates. After using the simple sugars, most of these forms cease active growth and are joined by the slower growing fungi, i.e. the cellulosers which in turn are overtaken by the lignin decomposers (Siu, 1951; Gascoigne and Gascoigne, 1960; Agrawal, 1971, 72). Studies on keratinophilic fungi from various habitats have received increasing attention in recent years. A search has been also made for keratinophilic fungi on feathers removed from living birds (Pugh, 1964, 65) and in nest material (Pugh, 1966).

Isolation from diverse substrates like soil, nails, hair, wool etc., can give valuable information on their distribution in nature. The surveys on the occurrence of karatinophilic fungi in Indian soils are made by Randhawa and Sandhu (1964) & Garg (1966). Various workers (Pugh and Mathison, 1962; Dabrowa *et. al;* 1964; Pawar *et. al;* 1965, and Padhye *et. al;* 1967) have also isolated the dermatophytic and keratinophilic fungi from marine soils.

The present studies were therefore, undertaken to investigate the prevalence of keratinophilic fungi from the forest litter soils of Sagar. Several birds frequently visit this area. Lot of detritus material gets buried along with the forest litter. Keratinic material like animal hair, cattle hair, blanket pieces, etc., were also carried over by neighbouring people. The forest under survey has also a natural rate of deposition of keratinous substances, such as rabbit fur and feathers which may drop there.

MATERIAL & METHODS

In these studies the samples of soils and keratinous substances were collected from various sites, preference being given to those areas which were frequently visited by birds and cattles. Isolation, purification, identification of fungi was done. Media which are suitable to the growth of keratinophilic fungi was investigated.

Collection of Samples :

Soil and forest litter samples were collected from different sites in the forest

surrounding the Patharia Hills. Isolations were also made from various decomposed keratinic substances like wool, feathers, hair, nails, horns etc., collected from various places. These decomposed keratinic substances and soil samples were brought to laboratory in new polythene bags and kept for further isolation work.

ISOLATION METHODS

(1) Isolation of fungi by baiting :

In this piece of work most of the isolates were collected by this method in which various keratinic substances (nail, wool, feather, horn and human hair) were used to trap the fungi which can easily colonise these substrates.

(2) Direct isolation from buried keratinic substances :

Pieces of decomposing keratinic substances (feathers, wool, nails, hair, and horns) from various places were brought in the laboratory, after removing the soil particles these were placed directly in the petridishes having Sabouraud dextrose agar medium and kept for incubation at 28°C for 8-10 days.

PURIFICATION AND IDENTIFICATION

In the Petridishes when the colony of any fungus was seen for the first time it was transferred to other fresh dish containing suitable media. Other routine mycological methods were also used for purification of different forms.

After ensuring complete purity of culture, final description and camera lucida sketches were made. Micromeasurements were recorded for each fungus on suitable medium. Identification were done with the help of literature available (Gilman, 1957; Subramanian, 1971 and Raper & Thom, 1949).

Media used :

(i) Sabouraud's dextrose agar :

Neopeptone (Difco)	:	10 gms.
Dextrose	:	40 gms.
Agar agar	:	15 gms.
Distilled water	:	1000 ml.

(ii) Potato dextrose agar with keratin :

Potato (Peeled & sliced)	:	200 gms.
Dextrose	:	20 gms.
Hair or Horn powder	:	5 gms.
Agar agar	:	15 gms.
Distilled water	:	1000 ml.

RESULTS & DISCUSSION

During the course of study 16 species of fungi were isolated (Table 1) from various keratin rich substances. These fungi were isolated, purified and kept in stock cultures after identification and descriptions. They are as follows :

Phycomycetes :

(1) *Rhizopus arrhizus* Fischer.
(2) *Cunninghamella bertholletiae.*

Ascomycetes :

(1) *Aspergillus awamori* Nakazawa.

(2) *Aspergillus ustus* (Bainier) Thom and Church.
(3) *A. nanus* Montagne.
(4) *Penicillium simplicissimum* (Oudem) Thom.
(5) *Chaetomium spirale* Zopf.
(6) *C. globosum* Kunze & Schm.

Deuteromycetes :

(1) *Fusarium Poae* (Peck) Wr.
(2) *F. Chlamydosporum* Wr. et. Rg.
(3) *Curvularia lunata* (Wakker) Boedijin.
(4) Sterile mycelial form.
(5) *Trichoderma harzianum* (Rifai), A new record from India. (Rao. et. al, 1975).
(6) *Chrysosporium* sp_1
(7) *Chrysosporium* sp_2
(8) *Malbranchia* sp.

These were isolated from forest litter of Sagar. Mostly members deuteromycetes were found to be dominent. This may be due to the fact that most of the deuteromycetes are saprophytic. Similar is the observation by various other workers (Randhawa and Sandhu, 1965; Garg, 1966; Pugh & Mathison, 1962; Dabrowa *et al.*, 1964; Padhye *et al.*, 1967).

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TABLE 1

List of isolated keratinophilic fungi. from Teak forest litter soil.

Baits used	Organisms isolated
Feathers	*Aspergillus awamori. A. nanus, Chrysosporium* sp_1, *Malbranchia* sp, *Chrysosporium* sp_2.
Human hairs	*Aspergillus ustus,* Mycelial sterile form, *Trichoderma harzianum.*
Human nails	*Cunninghamella berthollitiae, Rhizopus arrhizus.*
Wool	*Curvularia lunata.*
Horns	*Chaetomium spirale, C. globosum. Penicillium simplicissimum, Fusarium chlamydosporum, F. poae.*

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FUMIGANTS, FUNGICIDES AND ANTIBIOTICS AS AN AID TO ISOLATION OF SOIL MYCOFLORA

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ABSTRACT

Attempts were made to reveal a fuller picture of the soil mycoflora with the help of toxicants. Black cotton soil was treated with fumigants (CS_2, formalin, ethyl man), and antibiotics (antiamoebin, chlssicol, blitane, thiram, sultaf, blitox, cu-alcohol), fungicides (captan, cosan, braorampheniçol, oxytetracycline, penicillin, streptomycin, streptopenicillin) for various length of period and change in the mycoflora was recorded by making regular isolations on PDA. As opposed to the appearance of nearly half a dozen common fungi in the untreated soil sample presence of toxicants brought to light 24 fungi distributed amongst nine genera and two sterile mycelial forms. This included six species of *Aspergillus*, three species of *Fusarium*, two species of *Paecilomyces*, six species of *Penicillium*, and a species each of *Chaetomium, Cryptomella, Curvularia, Rhizopus* and *Trichoderma*. This study suggests that further extensive investigations of this type alone can provide a correct picture of the uncommon members of the soil mycoflora since conventional techniques do not allow isolation of more than 20-30 per cent fungi of the soil.

INTRODUCTION

The practical application inherent in soil microbes has led to their isolation by various techniques; of these, soil dilution (Waksman, 1927) and soil plate (Warcup, 1950) methods are in use today all over the mycological world. A discussion of these methods has been critically reviewed by Warcup (1960). Amongst various modifications attempted by soil mycologists, use of selective media has found place with plant pathologists (Tsao, 1970). It is the slow growing fungi which do not get a chance to appear in the isolation plates because of fierce competition with the fast colonizers. Heat and steaming treatments have been applied to overcome this difficulty. In the present communication, attempts have been made to suppress some of the common spore-forming and faster growing fungi by pretreating the soil with toxicants, i.e., fumigants, fungicides, and antibiotics. The main aim of this study was to reveal a fuller picture of the soil mycoflora than achieved by routine isolation techniques.

MATERIALS AND METHODS

Black cotton soil, collected locally around the University's Boy's hostel, was used in this study. The fungal flora of normal and chemically-treated soil was isolated on potato dextrose agar (PDA) medium; stock cultures were also maintained on this medium. Soil plate method was employed for isolating the mycoflora from normal and treated samples.

Twenty five g soil was taken in glass bottles for fumigation. After equilibrating the soil for 24 hour to attain desired moisture level, known quantity of the fumigant, i.e., carbon disulphide (CS_2), formalin, and ethyl alcohol, was added to the soil and the bottles were plugged.

After 6 days, plugs were removed from the bottles; soil samples were plated 2, 4 and 7 days after opening of the plugs.

The fungicides — captan, cosan, brassicol, blitane , thiram, sultaf, blitox, and cuman — were dry-mixed in soil to provide a final concentration of 1, 2 and 5 per cent. The soil samples were moistened and incubated at room temperature. After an interval of 4, 7 and 15 days, samples soil were taken out and plated to isolate the mycoflora.

The antibiotics were supplied to the soil in a final concentration of 0. 1, 0.01 and 0.001 per cent, respectively. The antibiotic solutions were prepared in distilled water, 0.1N NaoH or methanol; proper controls were run in each case. The antibiotics used were, antiamoehin, chloramphenicol, oxytetracycline, penicillin, streptomycin and strepto-penicillin. After allowing the samples the incubate for 4, 7, and 15 days, platings were made in the routine fashion.

RESULTS AND DISCUSSION

Fumigants :

An inverse relationship was noted between the dosage of CS_2 and the number of fungi recorded from the fumigated soil sample (Table I). Besides Aspergilli and Penicilli, a species of *Trichoderma* was regularly isolated except where 1 ml. of CS_2 per 25 g soil was used. The tolerance of this fungus to CS_2 has been reported by Saksena (1960). The presence of a species of *Fusarium* at even the highest concentration of the fumigant is noteworthy (Table 1).

Fumigation with formalin brought about domination of the mycoflora by *Paecilomyces varioti*; only a single species of *Penicillium* could, however, be recorded. The maximum number of fungi was recorded in alcohol-treated soil (Table I). Aspergilli dominated over Penicilli; *Paecilomyces varioti* exhibited maximum number of fungal colonies. A species of *Cryptomella* appeared for the first time in the fumigated soil. When viewed objectively it becomes clear that fumigation allowed isolation of many more fungi than normally recovered from this soil on PDA. This is specially striking for species of *Penicillium*.

Fungicides :

Blitan treatment resulted in the isolation of a small number of fungi (Table II): presence of *Fusarium* at even the highest concentration is striking. Phycomycetous

TABLE I

EFFECT OF FUMIGANTS ON THE ISOLATION OF SOIL MYCOFLORA

Organisms	Concentration of the fumigant (ml/25 g soil)												
	Control	Alcohol				CS_2				Formalin			
	0	0.5	1	2	5	0.05	0.1	0.5	1.0	0.5	0.1	0.5	1.0
Aspergillus fumigatus	—	—	X	X	—	—	—	—	—	X	X	X	X
A. niger	X	X	X	—	X	X	—	X	—	—	—	X	X
A. terreus	—	X	X	X	X	—	—	—	—	—	—	X	X
A. versicolor	—	X	X	—	—	—	—	—	—	—	—	—	—
Cryptomella sp.	—	—	—	X	—	—	—	—	—	—	—	—	—
Curvularia lunata	—	—	—	X	—	X	X	X	—	X	X	X	—
Fusarium sp. I	X	—	—	—	—	X	X	X	X	X	—	—	—
Fusarium sp. II	—	—	X	X	X	—	—	—	—	X	X	X	—
Paecilomyces varioti	—	—	X	X	X	X	—	—	X	X	X	X	X
Penicillium lilacinum	—	X	—	—	—	X	—	X	—	—	—	—	—
Penicillium sp. I	—	—	—	—	X	X	—	—	—	—	—	—	—
Rhizopus nigricans	X	—	—	—	—	X	X	—	X	—	—	—	—
Trichoderma viride	X	X	X	X	—	X	X	X	—	X	X	X	—

X = Present — = Absent

TABLE II

EFFECT OF FUNGICIDES ON THE ISOL

Organisms	CONCENTRATION OF FUNGICIDES (%)												
	Control	Blitan			Blitox			Brassicol			Captan		
	1	2	5	1	2	5	1	2	5	1	2	5
Aspergillus fumigatus	—	X	X	—	—	X	—	X	X	X	X	X	X
A.niger	X	—	—	X	—	X	X	X	—	X	X	X	X
A. terreus	—	X	—	X	—	—	X	X	—	X	—	X	—
A. versicolor	—	X	X	X	—	—	—	—	—	—	—	—	X
Aspergillus sp. II	X	X	X	X	X	X	X	—	—	—	X	X	X
Chaetomium jodhpurense	—	—	—	—	—	—	—	X	—	—	—	—	—
Cryptomella sp.	—	X	—	X	—	—	—	—	—	—	X	X	—
Curvularia lunata	—	X	—	X	—	—	—	—	—	—	—	—	—
Fusarium sp. I	X	X	X	X	X	X	X	X	X	X	X	X	—
Paecilomyces fusisporus	—	—	—	—	—	—	—	X	X	X	—	—	—
P.varioti	—	—	—	—	X	—	—	—	—	—	—	—	—
Penicillium chrysogenus	—	—	—	—	X	—	—	—	—	—	—	—	—
P. lilacinum	—	—	—	—	—	—	—	—	—	—	X	—	—
Penicillium sp. I	—	X	—	—	—	—	—	—	—	—	X	—	—
Penicillium sp. II	—	—	—	—	—	—	—	—	—	—	—	—	—
Penicillium sp. III	—	—	—	—	—	—	—	—	—	—	—	X	—
Rhizopus nigricans	X	—	—	—	X	X	X	X	X	X	—	—	—
Trichoderma viride	—	—	—	—	X	X	X	—	—	—	—	—	—
Mycelia sterilia I	—	—	—	—	—	X	—	—	—	—	—	—	—

X = Present — = Absent

TABLE II

THE ISOLATION OF SOIL MYCOFLORA

CONCENTRATION OF FUNGICIDES (%)												
Cosan			Cuman			Sultaf			Thiram			
1	2	5	1	2	5	1	2	5	1	2	5	
X	X	X	—	X	X	—	—	X	X	X	—	
X	—	X	—	X	—	X	X	X	—	—	—	
—	X	—	X	—	—	—	—	—	—	—	—	
X	—	—	—	—	—	—	—	—	—	—	—	
X	—	—	—	—	—	—	—	—	—	X	—	
—	—	—	—	—	—	—	X	—	X	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	X	—	—	
—	X	X	X	X	X	—	X	X	X	X	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	X	X	X	—	—	—	X	X	X	—	—	—
—	—	—	—	X	—	—	—	—	—	—	—	—
—	—	—	X	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	X	—	—	—	—	—	—	—	—
—	X	X	—	X	—	—	X	X	X	—	—	—
—	—	—	X	X	X	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—

forms and Penicilli were almost completely eliminated. This is in contrast to the results obtained with blitox where *Rhizopus* sp. appeared frequently in the isolation plates. Species of Penicillium were again suppressed but *T. viride* appeared regularly.

Brassicol appeared to be comparatively less toxic since the number of fungi recovered from the soils samples was much higher (Table II). The total picture of the mycoflora, however, did not differ from that noted for blitan and blitox. *Chaetomium Jodhpurence* was isolated at only one occasion whereas *Paecilomyces fusisporus* made its first appearance in brassicol-treated soil. The absence of Penicilli can be noted here as well. Captan, however, allowed this genus to appear in the plates. The majority of mycoflora none-the-less comprised of species of *Aspergillus*. Cosan-treated soil also behaved in a manner comparable to captan (Table II).

The minimum of fungi appeared in cuman-treated soil: the mycoflora consisted of two species of *Aspergillus* and a member each of the genera, *Fusarium, Rhizopus,* & *Trichoderma.* There was a total absence of species of *Penicillium* and *Paecilomyces.* Thiram-treated soil also exhibited a poor mycoflora; most of the fungi appeared at only a single occasion and comprised of species of *Curvularia, Fusarium* and *Penicillium.*

Antibiotics :

The antibiotics used in this study possessed anti-bacterial action alone. This choice was made to eliminate interaction of soil fungi with the resident bacterial flora rather than to suppress growth of the former in their natural invironment.

Penicillin treatment of the soil exhibited ten fungal species distributed in six genera (Table III). *Paecilomyces varioti* and *Rhizopus* sp. were more frequent than species of *Aspergillus* and *Penicillium.* As opposed to five Aspergilli, *P. lilacinum* alone represented the genus *Penicillium.* Two sterile mycelial forms were also recovered of which one produced rhizomorph-like aggregates of mycelium suggesting basidiomycetous nature: it did not, however, fruit in culture. Soil treated with streptomycin revealed lesser fungal forms (Table III). *Aspergillus fumigatus, Curvularia lunata,* and *Paecilomyces varioti* were at a single occasion only. The picture of the mycoflora observed in streptopenicillin-treated soil resembled the description provided for penicillin and streptomycin above. Aspergilli dominated the mycoflora. Chloramphenicol treatment of the soil revealed species of *Cryptomella* and the dark sterile mycelial form discussed in the earlier section was encountered in the oxytetracycline-treated soil. Two species of Fusarium were recovered from antiamoebin-treated soil for the first time.

The chemical treatment of the black cotton soil discussed above thus led to the isolation of 24 fungi which were distributed amongst nine genera and two sterile mycelial forms (Table IV). The list includes six species of *Aspergillus* three species of *Fusarium*, two species of *Paecilomyces,* six species of *Penicillium* and a species each of *Chaetomium*, *Cryptomella, Curvularia*, *Rhizopus* and *Trichoderma.* The results of this preliminary investigation give support to the idea that many more fungi can be isolated from the soil samples by treating them with toxicants since this checks or at least suppresses growth of faster colonizers.

TABLE III

EFFECT OF ANTIBIOTICS* ON THE ISOLATION OF SOIL MYCOFLORA

Organisms	Control	Anti-amoebin	Chloramphenicol	Oxytetracycline	Penicillin	Streptomycin	Streptopencillin
Aspergillus fumigatus	—	X	X	X	X	X	X
A. niger	X	—	X	X	X	X	X
A.terreus	—	—	—	—	X	—	X
A. versicolor	—	—	—	X	X	—	—
Aspergillus sp. I	—	—	—	X	—	X	X
Aspergillus sp. II	—	X	X	—	—	—	—
Chaetomium iodhpurense	—	—	X	—	X	—	X
Cryptomella sp.	—	—	X	X	—	—	—
Curvularia lunata	—	X	X	—	X	X	—
Fusarium oxysporum	—	—	—	—	X	—	X
Fusarium sp. I	X	X	X	—	—	—	—
Paecilomyces fusisporus	—	X	—	—	—	—	—
P. varioti	X	—	—	X	X	X	X
Penicillium lilacinum	—	X	X	X	X	—	X
Penicillium sp. I	—	X	—	—	—	—	—
Rhizopus nigricans	X	X	X	X	X	X	X
Trichoderma viride	—	—	X	—	—	X	X
Mycelia sterilia I	—	—	—	—	X	—	—
Mycelia sterilia II	—	—	—	X	—	—	—

* Antibiotics were added to the soil in a final concentration of 0.001, 0.01, and 0.1%. The results presented in this table have been summarized from the data recorded for these antibiotics at the concentrations indicated above.

X = Present — = Absent

TABLE IV

SUMMARY OF THE SOIL MYCOFLORA ISOLATED AFTER VARIOUS CHEMICAL TREATMENTS

Organisms	Fumigants			Fungicides								Antibiotics							
	Control	Alcohol	CS_2	Formaline	Blitan	Blitox	Brassicol	Captan	Cosan	Cuman	Sultaf	Thiram	Antiamoebin	Chloramphenicol	Oxytetracycline	Penicillin	Streptomycin	Streptopenicillin
Aspergillus fumigatus	—	X	—	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
A.niger	X	X	—	X	X	X	X	X	X	X	X	—	—	X	X	X	X	X
A. terreus	—	X	—	X	X	X	X	X	X	—	—	—	—	—	—	X	—	X
A. versicolor	—	X	—	—	X	—	—	X	—	—	—	X	—	—	X	X	—	—
Aspergillus sp. I	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	X	X
Aspergillus sp. II	—	—	—	—	X	X	—	X	—	—	X	X	X	X	—	—	—	—
Chaetomium jodhpurense	—	—	—	—	—	—	X	—	—	—	—	—	—	X	—	X	—	X
Cryptomella sp.	—	X	—	—	X	—	—	X	—	—	—	—	—	X	X	—	—	—
Curuvaria lunata	—	X	X	X	X	—	—	—	—	—	—	—	X	—	—	X	X	—
Fusarium oxysporum	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	X
Fusarium sp. I	X	—	X	X	X	X	X	X	X	X	X	—	X	X	—	—	—	—
Fusarium sp. II	—	X	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—
Paecilomyces fusisporus	—	—	—	—	—	—	X	—	—	—	X	X	X	—	—	—	—	—
P. varioti	—	X	X	X	—	X	—	—	X	—	X	—	—	—	X	X	X	X

Penicillium chrysogenum	—	—	—	—	X	X	—	—	X	X	—	—	—	—	—	—	—	—
P. javanicum	—	—	—	—	—	—	—	—	—	—	—	—	X	—	X	—	X	—
P. lilacinum	—	—	X	—	—	—	—	X	X	—	—	—	X	X	X	X	—	X
Penicillium sp. I	—	—	—	X	—	—	—	—	—	—	—	—	X	—	—	—	—	—
Penicillium sp. II	—	—	—	—	—	—	—	X	—	—	—	X	—	—	—	—	—	—
Penicillium sp. III	—	—	—	—	—	—	—	—	—	X	—	—	—	X	—	—	—	—
Rhizopus nigricans	X	X	X	—	—	X	X	—	—	—	X	—	X	X	X	X	X	X
Trichoderma viride	X	X	X	X	—	X	—	—	—	X	—	—	—	—	—	—	X	X
Mycelia sterilia I	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	X	—	—
Mycelia sterilia II	—	—	—	—	—	—	X	—	—	—	—	—	—	—	X	—	—	—

X = Present — = Absent

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COMPARATIVE MORPHOLOGY AND INTERRELATIONSHIPS OF THE CENTROSPERMALES IV. INTERRELATIONSHIPS

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How far embryological data support the assignment and arrangement of different families in the order Centrospermales is discussed in the following pages. Morphological and anatomical evidences have also been considered. Due to want of embryological data the families Achatocarpaceae, Agdestidaceae, Aquilariaceae, Barbeuiaceae, Batidaceae, Dysphaniaceae, Gonystylaceae and Gyrostemonaceae will not be discussed.

The families Aizoaceae, Amaranthaceae, Basellaceae, Caryophyllaceae (including Illecebraceae), Chenopodiaceae, Nyctaginaceae, Phytolaccaceae (including Petiveriaceae) and Portulacaceae have been included under the Centrospermae in Engler & Prantl's (1934) 'Die naturlichen Pflanzenfamilien', and by Wettstein (1924) along with a few other families (see part I of this series). All these families form a natural assemblage and show significant resemblances which will be clear from the following account.

1. Anther tapetum :

The tapetum is of the glandular type and its cells become 2-nucleate (sometimes 4 to 5-nucleate).

2. Quadripartition of microspore mother cells :

The divisions of the microspore mother cells are of the simultaneous type and quadripartition takes place by furrowing.

3. Male gametophyte :

The pollen grains are shed at the three-celled stage.

4. Pollen morphology :

The pollen grains are 3-colpate; exine is thicker than intine, usually punctitegillate and often provided with small spinules.

According to Erdtman (1952) pollen grains are more or less similar to those in :

(i) Aizoaceae are met with in the Nyctaginaceae, Phytolaccaceae and Portulacaceae.

(ii) Amarathaceae — Amaranthus type in the Chenopodiaceae and Gomphrena type in the Caryophyllaceae.

(iii) Basellaceae are found in the Portulacaceae, Amaranthaceae, etc.

(iv) Caryophyllaceae are present in the Amaranthaceae, Chenopodiaceae, Nyctaginaceae, Phytolaccaceae and Portulacaceae.

(v) Chenopodiaceae are met with in the Amaranthaceae, Caryophyllaceae and Phytollaccaceae.

(vi) Nyctaginaceae occur in the Caryophyllaceae, Phytolaccaceae and Aizoaceae.

(vii) Phytolaccaceae are found in the Aizoaceae, Chenopodiaceae and Nyctaginaceae.

(viii) Portulacaceae are met within the Aizoaceae, Basellaceae, Nyctaginaceae, Phytolaccaceae, etc.

5. Ovule :

The ovule may be anatropous or campylotropous; it is hemicircinotropous as in *Deeringia celosioides* (Bhargava, 1961). There are two integuments except in *Abronia umbellata* (Rocen, 1927) and *Boerhaavia* (Maheshwari, 1929; Bhargava, 1932) which are unitegmic. A third integument develops in some members of the Aizoaceae. The swollen and of the inner integument forms the micropyle. Periclinal divisions in the nucellar epidermis are common and a distinct nucellar cap is formed with the embryo sac deeply buried in the nucellus. In some members of the Aizoaceae 2-6 epidermal cells lying just above the embryo sac elongate radially and give a characteristic shape to the nucellus. Another noteworthy feature is the presence of an air space at the chalazal end in between the inner and the outer integument.

6. Megasporogenesis :

Usually there is a single archesporial cell, which always cuts off a wall cell which divides periclinally once or twice; in some members of the Nyctaginaceae and Caryophyllaceae a prominent nucellar beak is formed. The megaspore mother cell gives rise to a tetrad of megaspores, of which the chalazal functions. When a row of three megaspores is formed, the upper one is frequently binucleate.

7. Female gametophyte :

The development of the embryo sac conforms to the Polygonum type. The exceptions are *Aerva tomentosa* (Sachar & Murgai, 1958, 1959) where the embryo sac conforms to Adoxa or Allium type; in *Mesembrianthemum pseudotruncatellum* (Schmid, 1925) to Adoxa type and in *Phyllocactus* sp. (D'Hubert, 1896) to Allium type.

The mature embryo sac is mostly elongated and curved in accordance with the shape of the ovule. The polar nuclei fuse before fertilisation. There are three small and ephemeral antipodal cells except in a few members where they are large, persistent and occasionally increase in number.

8. Endosperm :

The endosperm is of the Nuclear type, wall formation is initiated at the micropylar end and may remain restricted only to this region or the entire endosperm may become cellular. Most of the endosperm is used by the growing embryo and only a few layers persist at the tip of the radicle[1]

1 See Bhargava (1936) for a detailed comparison of endosperm development in the order Centrospermales. Subsequent investigations confirm earlier findings.

TABLE I

TABLE SHOWING THE TYPES OF EMBRYOGENY IN DIFFERENT FAMILIES UNDER DISCUSSION

Family	Solanad	Caryophyllad	Chenopodiad	Asterad	Onagrad
Aizoaceae	Linum variation,*	X	X	X	X
Amaranthaceae	*	X	*	X	X
Caryophyllaceae	X	Sagina & Vaccaria variation	X	X	X
Chenepodiaceae	X	X	*	X	X
Cynocrambaceae	X	X	*?	X	X
Elatinaceae	Nicotiana variation	X	X	X	X
Geissolomataceae	X	X	X	Penaea variation	X
Illecebraceae	X	Sagina variation	X	X	X
Nyctaginaceae	X	X	X	Polygonum variation	X
Penaeaceae	X	X	X	Panaea variation	X
Petiveriaceae	X	X	*		Myosurus variation
Phytolaccaceae	X Phytolacca variation (New variation suggested by Kajale, 1954c)		X	X	Myosurus variation
Podostemonaceae	*	Drosera variation	X	X	X
Polygonaceae	X	X	X	Polygonum variation	X
Portulacaceae	Linum variation	Myriophyllus variation	X	Polygonum variation	X
Salicaceae	X	X	X	Polygonum variation	*
Tamaricaceae	Sherardia variation	X	X	X	X
Thymelaeaceae	X	X	X	Penaea & Erodium variation	X

* indicates only type, variation not known
X indicates absence
? doubtful

The reserve food material is stored in perisperm.

9. Embryo :

The embryogeny conforms to various types (See Table I). The embryo may have a short or massive suspensor; or the basal cell may be haustorial.

10. Seed :

The mature embryo is horse-shoe shaped. The seed coat comprises the outer layer of the outer integument and inner layer of the inner integument except in the Aizoaceae, Chenopodiaceae, Petiveriaceae and Phytolaccaceae where all the layers of the outer integument take part in the formation of the seed coat. Some members of the Aizoaceae develop a third integument or aril which also becomes a part of the seed coat.

11. Chromosome number :

The families Aizoaceae, Amaranthaceae, Caryophyllaceae, Chenopodiaceae, Phytolaccaceae & Portulacaceae are related to one another through such species which have basic chromosome number 9. Similarly the families Basellaceae, Caryophyllaceae and Portulacaceae are related to one another through species with chromosome number 12; and the Nyctaginaceae, Caryophyllaceae and Amaranthaceae through species with chromosome number 17 (see Table 2).

12. Vegetative anatomy :

The stomata are generally of the Rubiaceous or Ranunculaceous type and Caryophyllaceous type in the Caryophyllaceae (including Illecebraceae). Sen (1958) reported the occurrence of both Rubiaceous and Caryophyllaceous types, the latter predominates in *Alternanthera sessiles* (Amaranthaceae). The xylem vessels are medium to short and with narrow lumen; they may be solitary or in clusters and with simple perforations. However, in the Aizoaceae they may have bordered pits. Intravascular pitting is usually scalariform paratracheal wood parenchyma consists of only a few cells completing the sheath around the vessels, medullary rays are mostly 2 to 4 cells wide, and often very high composed of square or upright cells. The fibres are commonly septate and short have simple pits; but in some members of the Caryophyllaceae they show bordered pits. The endodermis is usually clearly defined except in the Basellaceae and Aizoaceae, pericycle is partly sclerenchymatous, development of cork is mostly sub-epidermal except in the Caryophyllaceae where it generally arises in the pericycle and raphides and crystal sand commonly occur in leaves and sometimes in stem also. A variable number of medullary vascular bundles are found in the Amaranthaceae, Caryophyllaceae, Chenopodiaceae, Nyctaginaceae and Phytolaccaceae. A characteristic type of anomalous secondary growth occurs in stems and roots in a large number of species in the Aizoaceae, Amaranthaceae, Chenopodiaceae, Nyctaginaceae and Phytolaccaceae. In the Caryophyllaceae (including the Illecebraceae) it is usually absent in the stem but may occur in the roots; and or sometimes in the old stems of certain species of *Silene, Spergula & Polycarpaea,* etc. (Metcalfe & Chalk, 1950). If the root is a conservative organ, as believed by most plant anatomists the hypothesis may

be ventured that in the ancestors of these plants anomalous secondary growth was more highly developed than at present and extended to the root and stem.

13. Nodal anatomy :

The plants are characterised without exception by showing three traced unilacunar nodal structure.

14. Seedling anatomy :

Seedling anatomy of all the families except Basellaceae has been studied and in all of them the transition between the root and the stem follow 'type 3' of Van Tieghem (1871).

15. Floral anatomy :

Broadly speaking the floral anatomy is also similar as each perianth leaf is three traced, stamen unitraced and carpel three traced. However, variations even within the same family are met with.

Most taxonomists accepted Molluginaceae and Ficoidaceae as sub-families (Molluginoideae and Ficoideae) of the Aizoaceae but Hutchinson (1926, 1959) raised them to family rank which has been supported by Joshi & V. R. Rao (1936) and Raghavan & Srinivasan (1940a) On the basis of chromosome number (n=9) Schwantes (1960) suggested the removal of *Mesembryanthemum* from the Ficoidaceae to a new family, the Mesembryanthaceae. A careful study of Table 3 would show that Hutchinson's (1926) raising the two subfamilies to family status was justified. Sharma's studies (1959, 1962b, 1963a) on the floral and nodal anatomy of some members of the Ficoidaceae confirm Schwantes separation of Mesembryanthaceae.

Thymelaeaceae :

The relationships of this family have always been disputed. Bentham & Hooker (1862-1883) placed it under Daphnales; Engler & Prantl (1887-1898), Rendle (1938) and Core (1955) under Myrtiflorae; Bessey (1915) under Celastrales, and Hutchinson (1926), Gundersen (1950) and Benson (1957) under Thymelaeles. Fuchs (1928) considered it to be related to and derived from the Elaeagnaceae, and Mauritzon (1938) suggested close relationship with the Combretaceae and their assignment to the Myrtales.

Hutchinson (1926) placed Nyctaginaceae along with the Thymelaeaceae, Penaeaceae and Geissolomataceae under the order Thymelaeales and in 1959 he segregated two other families the Aquilariaceae and Gonystylaceae from the Thymelaeaceae. Venkateswarlu (1947c) has shown that the

TABLE 2

Number of chromosomes in different members of the families under discussion

Family	Number of chromosomes	
	n	2n OR more
Aizoaceae		
Molluginoideae	9, 18	18, 36, 54, 64
Ficoidae (semisucculent)	8	16, 26, 32, 48
Ficoidae (succulent)	9, 18	18, 27, 36, 54, 72
Amaranthaceae	6, 7, 8, 9 10, 13, 17, 18, 21	12, 18, 20, 24, 30, 32, 34, 36, 72
Basellaceae	12	24, 36, 44, 48, 60
Cactaceae	11	22, 33, 44, 66, 88, 132, 264
Caryophyllaceae	12, 18, 24, 48	24, 28, 30, 36, 48, 51, 60, 90, 96, 126, 1
Chenopodiaceae	6, 9, 18	12, 18, 24, 36, 48, 54, 64
Cynocrambaceae	11	22
Elatinaceae	6	24, 36, 40
Frankeniaceae	5	20, 30
Illecebraceae	5, 8, 9, 11, 20, 28, 30	10, 16, 18, 22, 28, 32, 36, 40, 44, 48, 52, 56, 108, 126, 144
Nyctaginaceae	17, 29	20?, 34, 58
Petiveriaceae	9	72, 108
Phytolaccaceae	9	18, 36
Podostemnaceae	20	40
Polygnaceae	7, 8, 9, 10, 11, 17, 20	14, 16, 20, 23, 40, 44, 60, 132, 140
Salicaceae	19, 22	38, 57, 76, 42?, 44, 88, 144, 152, 176
Tamaricaceae	12	24
Thymelaeaceae	9	18, 27, 28?, 30?, 27, 52?, 72, 90, 108

Nyctaginaceae resembles the Thymelaeaceae in the following embryological features:

(a) Secretary anther tapetum of parietal origin (b) cytokinesis by furrowing, (c) 3-celled pollen, (d) formation of an obturator-like structure, (e) nucellar cap in the ovule, (f) formation of the micropyle by the inner integument alone, (g) more than three antipodal cells in some of the members *(Mirabilis jalapa, Oxybaphus viscosus, Boerhaavia diffusa, B.repanda, Oxybaphus nyctagineus)*, (h) Nuclear type of endosperm which later becomes cellular, and (i) Asterad type of embryo development. Venkateswarlu (1947a) also stated, "Hutchinson's action in placing the Nyctaginaceae together with the Thymelaeaceae, Penaeaceae, and Geissolomataceae is favoured by the embryogenic evidence" because in the Penaeaceae and Geissolomataceae an embryo development keys out in the Penaea variation of Asterad type.

I agree with the above view. However, in both Geissolomataceae and Penaeaceae the pollen grains are different and they also differ from those of the Thymelaeaceae and Nyctaginaceae. Besides, there are other important differences between the family Nyctaginaceae and the other three families which are listed in Table 4.

In view of the differences listed in Table 4 there is hardly any justification to place the Nyctaginaceae with the families Thymelaeaceae, Penaeaceae and Geissolomataceae as has been done by Hutchinson (1926, 1959) and it should be included in the order Centrospermae (Wettstein, 1924).

Caryophyllaceae : Engler and Prantl (1887-1898, 1934), Wettstein (1935), Rendle (1938), and Core (1955) included Caryophyllaceae under the Centrospermae. Wernham (1911) and Bessey (1915) placed the Caryophyllaceae near the Ranales and considered them to be the departure point for the Primulaceae and the more reduced Centrospermalean families. Eichler (1875), Pax (1893, 1927) and Rendle (1938) presumed that the Caryophyllaceae originated from the Phytolaccaceae (*Phytolacca*) by the conversion of the outer staminal whorl to petals and outer carpellary whorl to stamens.

Coulter & Chamberlain (1903) regarded the Caryophyllaceae as the most highly evolved family of the Centrospermae, and they did not recognise any relationship between the Ranales and Centrospermales. According to Pax & Hoffman (1934), the Phytolaccaceae and Caryophyllaceae followed parallel lines of evolution from the Chenopod-Amaranth group. They pointed out that the Caryophyllaceae show progressive complexity from simple to large and complete flowers (see also Wettstein, 1935).

Hutchinson (1926) regarded the Caryophyllaceae as derived from the Ranales, and the former gave rise to several lines of evolution culminating in Centrospermales, Geraniales and Primulales. Douglas (1936) and Dickson (1936) believed that the Primulaceae may have been derived from the Caryophyllaceae.

From a detailed study of several species of the Caryophyllaceae Thomson (1942) concluded that the floral anatomy supports "the usual taxonomic treatment of relationship within smaller groups in the family. The Alsineae are a more re-

TABLE 3

Character	Moluginaceae
Nodal anatomy	Unilacunar
Floral anatomy	Perianth 3-traced, tepal traces arise at different levels, staminal traces independent and 1-traced, carpels 3-traced, recurrent stelar bundles absent
Flower	Actinomorphic
Perianth	Almost free
Petaloid staminodes	Generally absent
Stamens	Hypogynous or slightly perigynous
Anther wall	4-layered
Pollen grains	3-colpate, exine smooth
Ovary	Superior
Ovules	Bitegmic, outer integument 2-layered, sometimes a small aril present
Nucellus	Massive, epidermal cells divide periclinally
Embryo suspensor	Uniseriate (Fig. 96)
Basic chromosome number	9

Ficoidaceae	Mesembryanthaceae
Trilacunar Perianth multi-traced tepal traces arise at the same level, adjacent staminal traces fused and 1-traced, carpel multi-traced 1 dorsal and several laterals, recurrent stelar bundles absent	Unilacunar Stamen 1-traced, carpel multi-traced, 2-dorsals and several laterals, recurrent stelar bundles present in many species
Actinomorphic	Actinomorphic
Segments uniting to form a tube	Segments uniting to form a tube
Absent	Present
Perigynous	Perigynous
5-layered	X
3-colpate, exine smooth	3-colpate, exine spinulate
Superior or inferior	Inferior
Bitegmic, outer integument 3-layered, aril present	Bitegmic, outer integument 3-layered, aril absent
Massive, 4-6 epidermal cells above the embryo sac elongate radially	Massive, 4-6 epidermal cells above the embryo sac elongate radially
Multiseriate (Fig. 97) 8	Uniseriate, at places biseriate 9

TABLE 4

Character	Nyctaginaceae	Thymelaeaceae
Vegetative anatomy	Anomalous secondary growth and medullary bundles present, fibres with simple pits, internal phloem absent	Anomalous secondary growth and medullary bundles absent, fibres with bordered pits, internal phloem present
Floral anatomy	Staminal traces arise independently, carpellary wall supplied by 1-3 traces, style supplied by only the dorsal trace, carpellary bundle does not divide	Staminal traces arise jointly with the sepal traces, carpellary wall supplied by 3-5 traces, style supplied by dorsal and ventral bundles, carpellary bundles divide in various ways
Carpel	Remains open on the posterior side	Closed on the posterior side
Pollen grains	3-4 colpate, 6 polyrugate or polyforate, longest axis 25-180u sexine as thick as nexine or thicker	Oligo-polyforate, 20-75u in diameter, sexine thicker than nexine, usually provided with vestigial spinuloid excrescences.
Embryo sac	Polygonum type	Polygonum type
Embryogeny	Asterad type Polygonum-variation	Asterad type Penaea or Erodium variation
Basic chromosome number	17, 29	9

Penaeaceae	Geissolomataceae
Anomalous secondary growth and medullary bundles absent, fibres with bordered pits, internal phloem present	Anomalous secondary growth and medullary bundles absent, fibres with bordered pits
X	X
X	X
3-colporate (colpi alternate with 3 colpoid grooves), subprolate (48 x 39u), rounded, hexangular in polar view, sexine thicker than nexine	3-colporate, oblate spheroidal-subprolate, diameter about 20.5u, sexine about as thick as nexine, finely and distinctly reticulate
Penaea type	Polygonum type
Asterad Type Penaea-variation	Asterad Type Penaea-variation
X	X

duced and anatomically more advanced group than either section of the Sileneae. The relationship of the Caryophyllaceae to the Primulaceae is upheld, but direct relationship to the Geraniaceae seems improbable, and to the Polemoniaceae remote".

Pax (1893) divided the Caryophyllaceae into the following sub-families and tribes :

I : ALSINOIDEAE — Flowers polysepalous; stamens often perigynous.

(a) Fruit a capsule opening by teeth.
1. Alsineae — styles free up to base; leaves exstipulate.
2. Spergulae — styles free up to base; leaves stipulate.
3. Polycarpeae — styles joined at the base.

(b) Fruit an achene or nut.
4. Paronychieae — flowers similar, leaves stipulate.
5. Dysphanieae — flowers similar, leaves exstipulate and alternate.
6. Scleranthеae — flowers similar, leaves exstipulate and opposite.
7. Pterantheae — flowers in 3's, the two laterals more or less abortive.

II. SILENOIDEAE — Flowers gamosepalous, hypogynous.

1. Lychnideae — calyx with commisural ribs.
2. Diantheae — calyx without commisural ribs.

Bentham and Hooker (1862-1883) grouped the Alsineae, Paronychieae, Dysphanieae, Scleranthеae and Pterantheae into an independent family the Illecebraceae retaining it under the curvembryeae. The rest of the tribes comprised the family Caryophyllae of the order Caryophyllinae in Polypetalae. Hutchinson (1926, 1959) accepted the independent status of Illecebraceae but placed it along with Polygonaceae in the order Polygonales; while the Caryophyllaceae along with Molluginaceae, Ficoidaceae, Portulacaceae and Elatinaceae was included in the order Caryophyllales. This is an unnatural separation of closely allied groups as would be borne out by the following resemblances between the Illecebraceae and Caryophyllaceae :

(a) Secretary type of anther tapetum.
(b) Simultaneous type of reduction divisions of microspore mother cells and quadripartition by furrowing.
(c) 3-celled pollen grains.
(d) Bitegmic ovules with a massive nucellus.
(e) Formation of a parietal cell from the sporogenous cell.
(f) Polygonum type of embryo sac.
(g) Nuclear type of endosperm.
(h) Silene, Melandrium and Heliosperma types of wall formation in the endosperm.
(i) Formation of diverticulae in the embryo sac.
(j) Caryophyllad type of embryogeny.
(k) Presence of perisperm as the region of food storage.
(l) Same type of floral anatomy.
(m) Unilacunar type of nodal anatomy.
(n) Van Tiegham's Type 3 of sedling anatomy.
(o) Similar anomalous secondary growth and general vegetative anatomy.

As far as the development of the male and female gametophytes are concerned there are some resemblances between the

TABLE 5

Character	Illecebraceae	Polygonaceae
Stipules	Do not form a tube round the stem, often scarious and bilobed	Form a tube (ochrea) around the stem
Node	Unilacunar	Typically multilacunar, sometimes trilacunar
Stomata	Caryophyllaceous	Ranunculaceous or rubiaceous
Anomalous secondary growth	Present	Absent
Internal bundles	Absent	Present in some species
Internal phloem	Absent	Present
Interfascicular phloem	Absent	Present
Floral anatomy	Sepals 3-traced; staminal traces arise jointly with petal traces and in one whorl (or series)	Sepals 3-traced; staminal traces arise independently of petal traces and in two whorls
Ovule	Campylotropous; many, rarely few or 1 in each ovary	Orthotropous; one in each ovary
Embryo	Caryophyllad type, basal suspensor cells large and haustorial; mature embryo curved like a horse-shoe	Asterad type, suspensor short, of a few cells, mature embryo slightly curved
Perisperm	Present	Absent

Illecebraceae and polygonaceae but they also differ widely in several important characters as will be clear from Table 5.

Therefore, there is no justification for separating the Illecebraceae from the Caryophyllaceae and placing with the Polygonaceae.

Bessey (1915) and Hutchinson (1959) placed the Elatinaceae along with Caryophyllaceae while other taxonomists assigned it to the Guttiferales, Parietales, Tamaricales or Geraniales. From the following Table 6 it would be clear that the Elatinaceae differs from the Caryophyllaceae in several respects :

TABLE 6

Character	Elatinaceae	Caryophyllaceae
Abnormal secondary growth	Absent	Present
Pollen	2-celled, more or less triangular, sexine as thick as nexine	3-celled, round, sexine thicker than nexine
Ovule	Anatropous	Campylotropous
Micropyle	Formed by both integuments	Formed by the inner integument only
Embryo	Capsella type; straight at maturity	Caryophyllad type, horse-shoe-shaped at maturity

Therefore, the Elatinaceae cannot be placed near the Caryophyllaceae.

In the second edition of Engler and Prantl's "Die naturlichen Pflanzen-familien,' Pax and Hoffman (1934) removed the genus *Dysphania* from the Caryophyllaceae and placed it in a new family Dysphaniaceae assigning it an intermediate position between the Chenopodiaceae and Caryophyllaceae under the Centrospermae. Other taxonomists like Rendle (1938), Gundersen (1950), Core (1957) and Hutchinson (1959) did not accept the independent status of the Dysphaniaceae. It is characterised by the exstipulate and alternate leaves, cyclic flowers with a single whorl of perianth of 1-3 segments, 1-3 stamens, and a 1-seeded fruit. Aellen (Erdtman, 1952) made a morphological study of the pollen of *Dysphania*. On the basis of this study Erdtman (1952) wrote, "The pollen grains in *Dysphania* are similar to grains in Chenopodiaceae and related families". So far we do not have any information about the embryology, vegetative, floral,

seedling and nodal anatomy and therefore the relationships of *Dysphania* cannot be evaluated.

CACTACEAE : This family includes plants of varied habit from the leafy *Pereskia* to the tall ribbed columns of *Pachycereus*, the flat joints of *Opuntia*, the phylloclades of *Epiphyllum*, and tubercled spheres of *Mammillaria*. Its relationships have been much debated and Maheshwari (1945) pointed out "F. Vaupel (1925), in the latest edition of Engler-Prantl's Pflanzenfamilien, writes that there is hardly a family in the plant kingdom, the allocation of which has allowed so much scope to individual tastes as this."

Bentham and Hooker (1882-1883) placed the Cacteae (Cactaceae) and Ficoideae (=Aizoaceae) together under the Ficoidales suggesting their close relationship. Wettstein (1924) included it under the Centrospermae, while other taxonomists (see Engler & Prantl, 1887-1898; Warming, 1904; Bessey, 1915; Rendle, 1938; Core, 1955; Hutchinson, 1959) placed it in a separate order. Engler and Prantl, Rendle and Core named it Opuntiales; Warming as Cactiflorae, and Bessey and Hutchinson as Cactales. Engler and Prantl placed the Opuntiales near the Passifloraceae, but Hutchinson (1959) assigned it an intermediate position between the Cucurbitales and Tiliales. Following Schuman (1894), Engler (1926) admitted some affinity with the Aizoaceae (through *Mesembryanthemum*) which has been accepted by several systematists who consider the family Cactaceae allied to Parietales.

Takhatajan (1959) included the Cactaceae under the Centrospermae and placed it near the Aizoaceae suggesting their close relationship. Schnarf (1931), Mauritzon (1934), Neumann (1935), Puri and Singh (1935), Maheshwari (1945, 1950), and Banerji and Sen (1954) have advocated that on embryological evidences the Cactaceae should be included in the Centrospermales. However, due to marked resemblances in floral construction, vascular anatomy of the flower and nodal anatomy Tiagi (1961) suggested its relationship with the Calycanthaceae. He (Tiagi, 1961) goes on to say that "This, however, does not mean that the present day Calycanthaceae are the progenitor of the present day Cactaceae, but both the families had a common ancestor in some primitive Ranalian stock. The affinities of the family Cactaceae are most clearly expressed by assigning it a position next to the Calycanthaceae within the order Ranales".

The embryological (Tiagi, 1954, 1957, 1958, 1961; Maheshwari and Chopra, 1955; Chopra, 1957) and anatomical evidences (Metcalfe & Chalk, 1950; Tiagi, 1958) lend a strong support to Wettstein's (1955) views. Buxbaum's (1944, 1948, 1949, 1953) studies on the morphology of Cacti and Martin's (1946) on seed confirm this alliance. The family Cactaceae possesses the following embryological characters which show Centrospermalean affinities :

(a) Anther wall 4-layered (including the epidermis).
(b) Secretary type of tapetum with 2 to 4-nucleate cells.
(c) Quadripartition of the microspore mother cells is simultaneous and by furrowing.
(d) Pollen grains 3-celled, 3-colpate, sexine thicker than nexine, usually punctigillate, often provided with small spinules.

(e) Ovule bitegmic with strongly curved massive nucellus, and micropyle formed by the swollen apex of the inner integument only.
(f) The hypodermal archesporial cell cuts off a wall cell.
(g) Formation of a nucellar cap resulting from periclinal divisions of the nucellar epidermis.
(h) Linear or a T-shaped tetrad of megaspores or sometimes a triad.
(i) Embryo sac of the Polygonum type.
(j) Nuclear type of endosperm.
(k) Presence of perisperm in the seed.
(l) Seed coat develops from the outer layer of the outer and inner layer of the inner integument.

An additional feature is the presence of an air space in between the two integuments at the chalazal end of the ovule.

A radial elongation of the nucellar epidermal cells capping the embryo sac followed by a periclinal division in later stages is common to Cactaceae and Aizoaceae.

Corner (1946) considers that the occurrence of the centrifugal stamens in different families indicates their common origin. This feature is an additional proof of the relationship between the Cactaceae and Aizoaceae.

The Centrospermales is considered related to the Cactaceae through *Mesembryanthemum*. According to Buxbaum (1953), in the Cactaceae the placentation is "median laminar — displayed to a pseudoparietal position" and "there is no true difference between the position of placentae in *Mesembryanthemum* in which the displacement occurs during development and the Cactaceae in which displacement appears to be of a primary nature."

Sharma's (1958) studies on the floral anatomy of *Mesembryanthemum* lend further support since it possesses recurrent stelar bundles more or less as in the Cactaceae. However, there is some difference between their origin. In *Mesembryanthemum* they arise midway up the hypanthium and in the Cactaceae in the upper region.

The family Cactaceae further resembles the Centrospermales in having the following anatomical characters (Metcalfe & Chalk, 1950; Tiagi, 1958 and others):

(1) Rubiaceous or Ranunculaceous type of stomata.
(2) Presence of mucilage cells in the leaf and stem in the Basellaceae and Portulacaceae.
(3) Vessels medium to extremely short with narrow lumen, solitary or in clusters, perforation simple, intervascular pitting usually scalariform.
(4) Wood parenchyma paratracheal forming a sheath around the vessels.
(5) Medullary rays mostly 6-10 cells wide, often very high and of square or upright cells.
(6) Fibres short and septate with simple pits.
(7) Occurrence of medullary bundles in the Amaranthaceae, Caryophyllaceae, Chenopodiaceae, Nyctaginaceae and Phytolaccaceae.
(8) Presence of cortical vascular bundels (Mesembryanthemum-Aizoaceae).
(9) Unilacunar node.

Chorinsky (1931) drew attention to the similarities in the origin of emergences of *Pereskia* and *Rhipsalis* of the Cactaceae and *Anacampseros* of the Portulacaceae. Thus the available evidence indicate that the Cactaceae is a connecting link between the Aizoaceae and Portulacaceae. Neumann (1935) suggested the following specific similarities between the Portulacaceae and Cactaceae.

(a) Microspore mother cells in one to two (rarely more than two) rows.

(b) Micropyle in close proximity to the funiculus.

(c) Megaspore tetrad T-shaped.

(d) Synergids with long beaks.

(e) Embryo sac constricted in the middle.

Drawing attention to the dissimilarities with the Passiflorales, Maheshwari (1950) sated that (a) the nucellar epidermis does not undergo periclinal divisions; (b) usually the uppermost megaspore of the tetrad produces the embryo sac; (c) the ovule is anatropous with a symmetrical nucellus, and (d) the outer integument grows beyond the inner one and forms the micropyle (see Schnarf, 1931).

PHYTOLACCACEAE : Heimerl (1934) removed *Achatocarpus* and *Phaulothamnus* from the Phytolaccaceae to a separate family, the Achatocarpaceae; and the five Australian genera *Codonocarpus, Cypselocarpus, Didymotheca, Gyrostemon* and *Tersonia* into the Gyrostemonaceae. Hutchinson (1959) accepted the family status of both but removed the Achatocarpaceae to the Bixales. He further removed 13 genera and erected three new families the Agdestidaceae with the single genus *Agdestis*, and Barbeuiaceae with the genus *Barbeuis*, and Petiveriaceae with 11 genera — *Gallesia, Hillaria, Ledenbergia, Lophiocarpus, Microtes, Monococcus, Petiveria, Rivina, Schindleria, Seguieria* and *Trichostigma*. Thus only three genera, *Anisomeria, Ercilla* and *Phytolacca*, were left in the Phytolaccaceae. The chief morphological characters of the above families are compared in Table 7, from which it is clear that the Phytolaccaceae and Petiveriaceae resemble each other in (a) microsporogenesis and development of the male gametophyte, (b) pollen morphology, (c) structure of ovule, (d) macrosporogenesis and formation of embryo sac, (e) development of endosperm and embryo, (f) the structure of the seed, (g) basic chromosome number, and (h) floral, seedling, nodal and vegetative anatomy. However, in the Phytolaccaceae the ovary is two to many locular while in Petiveriaceae it is unilocular. Therefore, their separation by Hutchinson is hardly justified. Table 7 also shows that the Achatocarpaceae and Gyrostemonaceae differ from the families Agdestidaceae, Barbeuiaceae, Petiveriaceae and Phytolaccaceae in having unisexual dioecious or monoecious flowers and absence of abnormal secondary growth. About the pollen grains of Gyrostemonaceae Erdtman (1952) mentions that they are unique (with slight resemblance to the grains of the Batidaceae. He also emphasized that pollen morphology does not favour the separation of *Achatocarpus* and *Phaulothamnus*

Table 7

Showing the chief morphological and anatomical characters in the

Characters	Achatocarpaceee	Gyrostemonaceae	Phytolaccaceae
Habit	Small trees or shrubs	Trees, shrubs or undershrubs	Herbs, shrubs or rarely trees
Stipules	Absent	Minute or absent	Absent
Leaves	Alternate, entire pinnately nerved	Alternate, entire more or less succulent	Alternate, entire pinnately nerved
Abnormal secondary growth	Absent	Absent	Present, except in *Phytolaca dioica*
Bracts and Bracteole	Present	Present	Present
Flowers	Dioecious	Unisexual, dioecious or monoecious	Bisexual, rarely dioccious
Calyx	5-4 partite, segments imbricate persistent in fruit	Lobed or truncate, persistent in fruit	10-4 partite, green or somewhat coloured persistent
Corolla	Absent	Absent	Absent
Androecium	Stamens 20-10, filaments filiform, connate at base, anthers basifixed	Stamens 6 or more in 1 or more series around a flat central disc-like axis	Stamens 3- many on a fleshy disc, filaments free or connate at the base, dorsifixed
Pollen grains	3-colpate, forate, sexine thicker than nexine	3-colporate, crass-exineus psilate	3-colpate, spheroidal subprolate
Gynoecium	Bicarpellary ovary superior compressed, unilocular, one ovule	Bi-or polycarpellary ovary superior, 1 ovule in each locule	Carpels 2-10, ovary 2-many locular, globose, superior, ovule 1 in each locule
Seed	Aril absent	Aril basal and membranous	Aril absent

Phytolaccaceae and the families separated from it

Petiveriaceae	Barbeulaceae	Agdestidaceae
Shrubs often climbers	Trees	Twinning herbs with large turnip-like root stock.
Minute or absent	Absent	Absent
Alternate, entire rarely crenate	Alternate. entire petiole articulated at the base	Alternate, entire petiole twisted near the base
Presen in some	Present	Present
Present	Present	Present
Bisexuai, rarely unisexual	Bisexual	Bisexual
5 to 4 partite, green or coloured, persistent	5, orbicular spreading in fruit persistent	5 to 4 partite, persistent, half superior
Absent	Absent	Absent
Stamens 25 to 4, filaments free or slightly connate at the base, dorsifixed	Stamens numerous, in several series on an annular disc, anthers linear	Stamens 20 to 15 in more than one series on a perigynous disc
Colpate, subprolate; rugate forate, spheroidal	3-colporoidate	3-colpate
Carpels 1-5, ovary superior, unilocular, 1 ovule in each carpel,	Bicarpellary, ovary superior, bi-locular, ovule one in each chamber	Carpels 3-4, ovary 4-3 locular, half inferior, 1 ovule in each chamber
Aril absent	Aril fleshy	Aril absent, globose

from the Phytolaccaceae. The other two families, Agdestidaceae and Barbeuiaceae are also closely related to the Phytolaccaceae will also be clear from Table 7. The relationships of the families Achatocarpaceae, Agdestidaceae, Barbeuiaceae and Gyrostemonaceae cannot be discussed for want of embryological data.

CYNOCRAMBACEAE : This family comprises a single genus *Thelygonum* which has been placed in the Urticaceae (Bentham & Hooker, 1862-1883), Phytolaccaceae (Warming, 1904), Chenopodiaceae, Begoniaceae, Santalaceae, and Monimiaceae (see Engler & Prantl, 1887-1898). Hallier (1912) derived it from the Haloragidaceae. Schneider (1914) and Ulbrich (1934) described the morphology and anatomy of *Thelygonum* and on exomorphic rather than anatomical grounds suggested that the Cynocrambaceae may be related to the Haloragaceae (particularly to *Hippuris*).

Thelygonum does not show any important anatomical similarities with the Urticaceae and does not justify its inclusion in this family (see Bentham & Hooker, 1862-1883).

Benson (1957) designated Cynocrambaceae as Thelygonaceae, placed it after the Caryophyllales and pointed out that its position is uncertain. Embryologically it is characterised by (a) a secretary tapetum, (b) simultaneous type of reduction divisions of microspore mother cells, (c) 3-celled pollen, (d) campylotropous unitegmic ovule, (e) Polygonum type of embryo sac, (f) 3 uninucleate antipodals which later become 4 to 6-nucleate, (g) nuclear type of endosperm which later becomes cellular and stores reserve food, (h) horse-shoe-shaped embryo, (i) a thin papery layer of perisperm, (j) 3-traced perianth, 1-traced stamen, and carpel with a dorsal and ovular trace, (k) a continuous xylem cylinder, (l) larger amount of chlorophyll in the pith than cortex and (m) absence of abnormal secondary growth (cf. Chenopodiaceae).

Concerning the morpohlogy of pollen Erdtman (1952) stated, "The pollen grains in *Thelygonum* are of a more or less unique type not similar to those in Chenopodiaceae. Haloragidaceae, Hippuridaceae, Phytolaccaceae, Urticaceae, etc. They have possibly a slight similarity to some pollen type in Polygonaceae". We do not have adequate information about the nodal, seedling, vegetative and floral anatomy and embryogeny of *Thelygonum*. Therefore, its relationships must await further investigation.

BATIDACEAE : This family consists of the monotypic genus *Batis maritima*. The flowers are minute, unisexual and actinomorphic in catkin-like spikes.

Bentham and Hooker (1862-1883) assigned the Batidaceae an intermediate position between the Phytolaccaceae and Polygonaceae, and Baillon (1888) between the Salicaceae and Podostemonaceae. From a study of vegetative, anatomical and floral characters, Dammar (1893) concluded that *Batis is* quite different from other dicotyledons. He placed the Batidaceae between the Amaranthaceae and Phytolaccaceae. While warming (1904) placed the Batidaceae between the Chenopodiaceae and Phytolaccaceae, Hallier (1912) stated that it is related to the Chenopodiaceae. Bessey

(1915) placed it provisionally at the end of Caryophyllales. Engler and Gilg (1924) raised this family to an ordinal rank and placed the order Batidales after the Juglandales with the comment "Steht vollig isoliert". Hjelmquist (1923) regarded the Batidaceae to be related to the Juglandales and Fagales.

Uphof (1930) described the habit, ecology and organography of *Batis*, summarised the views of earlier workers on its affinities, but did not express his own views on its relationships. Johnson (1935) also reviewed the earlier literature and stated "Kunth (1816, p193) places *Batis* among the Chenopodiaceae. Sprengl (1826, p. 901) thinks *Batis* may belong among the Coniferae. Seubert (1884, p. 753) compared the male spike of *Batis* with that of *Sacrobatus* and that of certain Chenopodiaceae and suggests that *Batis* resembles such Chenopodiaceous genera as *Salicornia*". The earlier descriptions of *Batis* characterize its leaves as exstipulate but Johnson (1935) reported them to be stipulate and pointed out: "This supposed lack of stipules has of course played a definite part in determining where the Batidales should be placed among the orders of the Dicotyledoneae". Hutchinson (1959) included it in the order Chenopodiales assigning it an intermediate position between the Cynocranbaceae and Basellaceae.

Johnson (1935) reported that in *Batis maritima* the pollen is 2-nucleate and the seed is devoid of endosperm or perisperm. Erdtman (1952) mentioned that to some extent the pollen of *Batis* resembles that of *Gyrostemon* on the one hand (psilate grains) and with those of the Polygonaceae on the other (rupate grains). Owing to lack of information on the embryology and floral, nodal, seedling and vegetative anatomy it is not possible to discuss the relationships of this family.

TAMARICACEAE : Along with the families Caryophyllaceae and Portulacaceae, Bentham and Hooker (1862-1883) assigned the Tamaricaceae to the cohort Caryophyllineae, Hallier (1905) included it in the Centrospermae, and Bessey (1915) in the Caryophyllales. Engler and Diels (1936), Rendle (1938), Gundersen (1950), Lawrence (1951), and Hutchinson (1959) raised it to the ordinal rank (Tamaricales) and placed it before the Violales and Polygalales.

The Fritillaria type of embryo sac does not occur in any family of the Parietales or Caryophyllales (of Bessey) except the Tamaricaceae: nor is it found in any of the allied orders (Capparidales and Violales. More work on the other two *(Hololachne* and *Reaumuria)* genera of this family will facilitate a consideration of its relationships. For the present Hutchinson's erection of a separate order Tamaricales seems to be justified.

FRANKENIACEAE : Hallier (1912) placed the Frankeniaceae in the Guttales, derived it from the Linaceae through the Tamaricaceae, and considered it to be the most advanced family of the order. Bessey (1915) placed it along with the Tamaricaceae and Elatinaceae in the Caryophyllales; and Gundersen (1927) suggested its resemblances with the Caryophyllaceae, Mauritzon (1933) suggested its assignment to the Parietales; Rendle (1938), following Wettstein (1924), included it in the Parietales; Hutchinson (1959) grouped the Fran-

keniaceae and Tamaricaceae along with Fouquieriaceae in the order Tamaricales.

The Frankeniaceae differs from the Caryophyllaceae as in the former the pollen grains are binucleate, the female archesporial cell does not cut off a wall cell, epidermal salt glands are present, and the abnormal secondary growth of the type found in Caryophyllaceae is absent. On the other hand, anatomically and specially in the presence of epidermal salt glands, and pollen morphology it resembles the Tamaricaceae, while embryologically especially in the development of the embryo sac it differs from the Tamaricaceae. Information on the embryology of *Frankenia hirsuta* only is available and it is either meagre or lacking on the seedling, nodal and floral anatomy, therefore, it is not possible to discuss the relationships of this family.

SALICACEAE : Bentham and Hooker (1862-1883) included the Salicaceae among the Anomalous Monochlamydeae, Hallier (1912) in the Passionales, Bessey (1915) in the Caryophyllales, while most other taxonomists accept a separate order, the Salicales. On the basis of extensive morphological studies, Fischer (1928) concluded to reduction, and in this family *Populus* is the most primitive genera. Hjelmquist (1943) pointed ont that the cup or the finger like gland which is characteristic of this family is "formed by the reduction of an undifferentiated bracteal envelope and that it is not quite appropriate to designate them as perianth". Penhallow (1905) presented the view that the Salicaceae were in the process of development during the tertiary in North America but that in their present condition they are of recent origin. He also stated that in Cretaceous times the family was compatible with a much warmer climate than at present as evidenced by the presence of the more primitive forms in the tropics. Nagraj (1952) stated : "The Salicaceae give evidence of being a fairly highly evolved instead of a primitive family and should, therefore, occupy a higher position than that usually accorded to it by the Engler and Prantl's system of classification. Within the family is more primitive than Salix".

The Salicaceae differs from the Centrospermae in several important features : (a) unisexual flowers which lack perianth and are arranged in catkins, (b) 2-celled, non-aperturate pollen grains, (c) parietal placentae, (d) Onagrad type of embryo which is straight, (e) comose seed, and (f) absence of abnormal secondary growth. On the basis of these differences the Salicaceae should not be included in the Centrospermales and be kept in the Salicales as done by most taxonomists.

PODOSTEMONACEAE : (Podostemaceae) — Engler & Prantl (1887-1898) assigned this family to the Rosales, Warming (1904) regarded it to be closely related to the Saxifragaceae, Bessey (1915) assigned it to the Caryophyllales, and along with the Hydrostachyaceae, Hutchinson (1926) placed it in a new order the Podostemales. Hutchinson (1926, 1959) regarded the Podostemaceae to be much reduced apetalous type of the Saxifragales with apetalous type of the Saxifragales with embryology of the Crassulaceae and Saxifragaceae by Mauritzon (1933) has brought out certain features which make it almost certain that the Podostemaceae are much reduced apetalous derivatives of the Crassulaceae.

The following embryological features suggest that the Podostemaceae are not related to the Caryophyllales : (a) reduction divisions of the pollen mother cells are of the successive type, (b) pollen grains are bicelled and remain attached in pairs, (c) female archesporial cell does not cut off a wall cell, (d) development of embryo sac corresponds to a reduced Allium type, (e) endosperm fails to develop, and (f) a pseudo-embryo sac is formed. Mauritzon (1939) held the view that the Podostemaceae and Crassulaceae are closely related and should be placed in the Rosales. Subramanyam (1962, 1963) also regarded the families Saxifragaceae, Crassulaceae, Podostemaceae and Hydrostachyaceae to be closely allied to one another. He also pointed out the characters in which the Podostemaceae differs from the Crassulaceae.

The Podostemaceae should not be kept in the Caryophyllales in view of the differences pointed out above, and should be placed in the Rosales in the light of the researches of Mauritzon (1933, 1939) and Subramanyam (1962, 1963) as stated above.

HYDROSTACHYACEAE : Warming (1904) recognised it as a distinct family; Bessey (1915) placed it along with the Chenopodiaceae, Amaranthaceae and several other families in the Caryophyllales; Wettstein (1924) and Rendle (1938) assigned it to the Rosales; Mauritzon (1938, 1939) advocated "that the Hydrostachyaceae should be placed among the Rosales, that the agreement between Hydrostachyaceae and the Crassulaceae in two such characters as the type of endosperm, and in particular the suspensor haustorium was of significant importance to retain its place among the Rosales". He also stressed its close relationship with the Podostemaceae. Subramanyam (1962, 1963) emphasized its relationships with the Podostemaceae, Crassulaceae and Saxifragaceae.

The following features clearly indicate that the Hydrostachyaceae is not at all related to the Chenopodiaceae, Amaranthaceae and other families of the Centrospermae : (a) naked dioecious flowers, (b) male flower consists of a single stamen protected by a bract, (c) female flower consists of two similarly protected carpels united to form a unilocular ovary with median placentae bearing numerous ovules, (d) ovules unitegmic, (e) female archesporial cell directly functions as the megaspore mother cell, and (f) the absence of abnormal secondary growth.

(to be continued)

ON THE STATISTICAL ASSESSMENT OF SEASONAL VARIATIONS IN THE MAXIMUM LENGTH OF THE PROXIMAL PARS DISTALIS CELLS IN CONJUNCTION WITH THE REPRODUCTIVE CYCLE OF INDIAN FRESH-WATER GOBY, *GLOSSOGOBIUS GIURIS (Ham.)*.

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ABSTRACT

Seasonal changes in the maximum length of the basophils and acidophils have been studied statistically in order to ascertain the cytological seasonal variations in the proximal pars distalis of *Glossogobius giuris*. Both the acidophils and basophils have been found to exhibit seasonal changes in their size with a close relationship with the reproductive cycle of the fish. The increase in the cell size of the basophils is associated with the maturation process of the gonads in the pre-spawning period (January to May) and spawning activity in the spawning period (June to September). The increase in size of the acidophils is related with the high metabolic activities of the fish including growth, search for food and mate involving longer swimming movements of the fish.

INTRODUCTION

A little information is available on the statistical assessment of the cyclical activity of the pituitary cells (Rasquin, 1949; Scruggs, 1951; Olivereau, 1954; Bhargava, 1966; Bhargava and Raizada, 1973 and Sahai 1974) in comparison to that of the exhaustive studies on the pituitary-gonad relationship in teleosts.

In this paper an attempt has been made to study the cell-size variations statistically in relation with the reproductive cycle of Indian fresh-water goby, *Glossogobius giuris* (Ham.).

MATERIAL AND METHODS

The gobies were collected locally from Sagar lake (Saksena, 1971). The histochemical techniques used for the study of the pituitary gland (Saksena, 1976a, 1977a) and reproductive cycle (Saksena, 1976b, c) have already been described For the present study on cell-size variation, only those cells of the proximal pars distalis were considered which were cut along their maximum length. A monthly sample of ten fishes was examined through the year. After surveying under high magnifications (X 675) five basophils and five acidophils from nine equidistant planes were selected

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for this investigation.

The fishes of each monthly sample were compared with one another to make sure that they are not significantly different from each other at 5% level. This was determined by using following formula for student's 't' test (Brownlee, 1947).

$$t = \frac{\overline{X}_1 - \overline{X}_2 \cdot \sqrt{\frac{N_1 \; N_2}{N_1 + N_2}}}{\sqrt{\frac{(X_1^2) - \left(\frac{X_1}{N_1}\right)^2 + \left(X_2^2\right) - \left(\frac{X_2}{N_2}\right)^2}{N_1 + N_2 - 2}}}$$

where X_1 and X_2 = mean maximum length in u of the cells of two different fishes compared, N_1 and N_2 are number of cells in each fish (45) and $N_1 + N_2 - 2 =$ are degrees of freedom (88) allowed for determining the significant probability.

The number of fishes not significantly different in each monthly sample was found to vary from 8 to 10. The standard deviation for the monthly mean maximum length value of the basophils and acidophils of the fishes which were not significantly different was calculated by the following formula.

$$\text{S. D.} = \delta = \sqrt{\frac{(X^2) - \frac{(X)^2}{N}}{N}}$$

where X is length of each one of the cells in u and N is 450 or less depending on the number of the fishes studied in the monthly sample. The standard error was calculated by the following formula

$$\text{S. E.} = \frac{\delta}{\sqrt{N}}$$

where is the standard deviation and N is number of the cells (450 or less).

The mean maximum length of the basophils and acidophils, standard deviation and standard error of the mean maximum length for a population of the cells in each month has been shown in Fig. 1 and 2.

In order to ascertain whether the curves showing the mean maximum length in different months are significant, a monthly sample of the cells was compared with another monthly sample throughout the year of applying the same student's 't' test.

OBSERVATIONS AND CONCLUSIONS

The cytological variations in the cells of the proximal pars distalis have already been described (Saksena, 1977 b) in relation with the reproductive cycle of the fish (Saksena, 1976b, c). The basophils as observed after cell size measurements show a considerable fluctuation in their maximum length also.

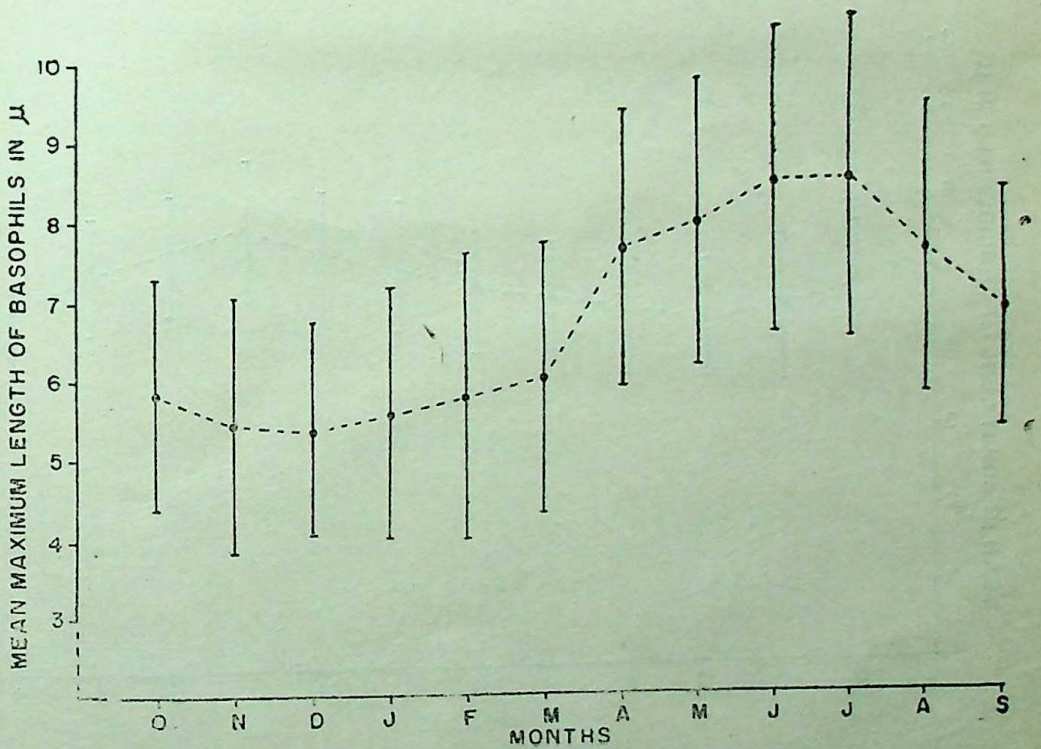
During the post-spawning period (October to January) the maximum length of basophils decreases gradually from October to December and thereafter the maximum length increases considerably in January. The variations in the maximum length of the basophils during the post-spawning period are significantly different. The gradual decrease in the size of basophils upto December shows that after the spawning period (when the secretion has been completely released) the basophils are in a resting period until December when the secretory activity is at its lowest ebb (Fig. 1). The secretory granules start appearing in the month of January with an accumulation of these granules in the basophils, which corresponds with the slow activity of the gonads. The process of game-

togenesis, during this period, is concerned in producing only early stages in greater number.

There is a gradual increase in the size of basophils throughout the pre-spawning period (February to May) which confirms the cytological observations that the granulation of the basophils increases gradually. The process of granulation, during this period, seems to be quite significant as the values of 't' for the mean maximum length variations on comparison with each other are found to be significantly different. During this period the gonads are also in an active phase of their maturation resulting in the formation of greater number of advanced stages of gametogenesis.

The basophils increase in size steadily till July, during the spawning period (June to September), when they are 8.68u in length. The size of the basophils then decreases till the end of this period when it is 7.10u. The values of 't' for basophils are significantly different when the monthly samples are compared with each other. However, when the sample of June is compared with that of July, the value obtained is not significantly different. This simply implies that the changes that are going on in the basophils during these months are not very different for this period of the reproductive cycle. The maximum cell size in July clearly indicates the greatest reproductive activity during this month. This condition is in confirmity with the cytological observations which indicate that during July and August the degranulation of basophils is maximum which results in the maximum degree of completion of gameto-

ed that the simplicity of the flowers is due



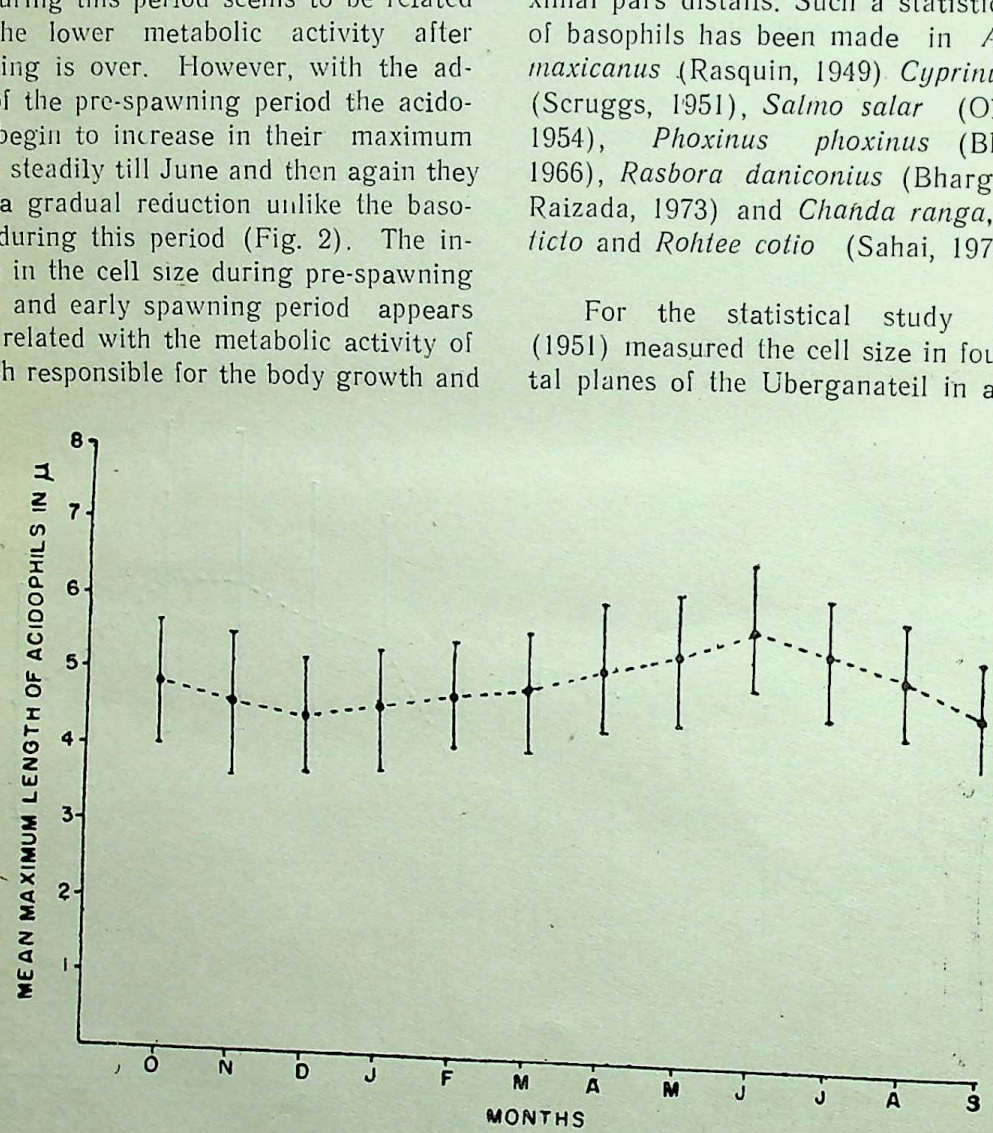
genesis and spawning during this period.

The acidophils of the proximal pars distalis do not show any striking cytological variation which could be correlated with the reproductive cycle of the fish. However, a cyclical change in their maximum length has been noticed. During the post-spawning period the cell size of acidophils reduces gradually until December. The reduction during this period seems to be related with the lower metabolic activity after spawning is over. However, with the advent of the pre-spawning period the acidophils begin to increase in their maximum length steadily till June and then again they show a gradual reduction unlike the basophils during this period (Fig. 2). The increase in the cell size during pre-spawning period and early spawning period appears to be related with the metabolic activity of the fish responsible for the body growth and reproductive behaviour including search for food and search for a mate involving longer swimming movements.

DISCUSSION

Very little work is known in fishes regarding the quantitative assessment of the seasonal changes in the cell size of the proximal pars distalis. Such a statistical study of basophils has been made in *Astyanax maxicanus* (Rasquin, 1949) *Cyprinus carpio* (Scruggs, 1951), *Salmo salar* (Olivereau, 1954), *Phoxinus phoxinus* (Bhargava, 1966), *Rasbora daniconius* (Bhargava and Raizada, 1973) and *Chanda ranga*, *Puntius ticto* and *Rohtee cotio* (Sahai, 1974).

For the statistical study Scruggs (1951) measured the cell size in four sagittal planes of the Uberganateil in alternate



fields. In this method the normal possibility is that in these sections, the cells were cut in different planes and hence the cell size after measurement may not represent its maximum length. Bhargava (1966) in an improved method, has taken only those cells of the meso-adenohypophysis into consideration which were found abutting on the processes of neurohypophysis. The criterion of selecting cells found abutted on the neurohypophysial processes is well justified because during histogenesis, the neural part, interdigitates with the glandular part of the pituitary gland with the mesodermal stratum in between them and therefore such cells alone represent their actual maximum length.

Both the basophils and acidophils have been found to show cyclic changes in their maximum length during the reproductive cycle. A gradual increase in the cell size of the basophils during pre=spawning period and spawning periods is correlated with the process of growth and the maturation of gonads and spawning of *Glossogobius giuris* during these periods respectively. The changes in the maximum length of the acidophils with the advent of the pre=spawning period and spawning period appears to be related with the body growth and reproductive behaviour including search for food and mate and also the spawning behaviour, which is in confirmity with the observations of Bhargava (1966), Bhargava and Raizada (1973) and Sahai (1974).

ACKNOWLEDGEMENTS

I extend my sincere thanks to Dr. H. N. Bhargava, Head of the Department of Zoology, University of Saugar, Sagar (M.P.), for this encouragement and critical insights of the manuscript. The financial assistance during the tenure of this work, from C.S.I.R., India is gratefully acknowledged.

Explanation to figures

Fig. 1 and 2 : Curves for the basophils (Fig. 1) and acidophils (Fig. 2) of the proximal pars distalis of the pituitary gland in *Glossogobius giuris* (Ham.) to show the seasonal changes in their maximum length during different months of a year. The standard deviation for the mean maximum length of each month is shown by vertical lines.

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INSECT FAUNA OF SAUGAR DIVISION—I. HEMIPTERA

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The insects belonging to order Hemiptera are very important economically. A survey of these insects have been made in Saugor division. Insects collected and identified have been indexed in Table I.

ACKNOWLEDGEMENT

The author is thankful to Dr. S. A. Faruqui, Dr. M. M. Singh and Miss C. K. Swamy (Mrs. Tiwari) for the help in the collection of insects and also to the Director, Commonwealth Institute of Entomology (British Museum, Natural History, London) for the identification of insects.

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TABLE –

Sub order	Super family	Family	Insect species
Homoptera			
	Cicadoidea	Cicadellidae (Jassidae)	*Exitianus* sp.
		Membracidae	*Oxyrhachis* sp.
			Otinotus sp.
			Leptocentrus obliquus (Walk).
		Aphrophoridae (Cercopidae)	*Poophilus* sp.
	Fulgoroidea	Eurybrachidae	*Eurybrachys apicalis* (Walk.)
			Eurybrachys spinosa (Fabr.)
Heteroptera			
	Gymnocerata (Division)	*Reduviidae*	*Ectomocoris quadrigullatus* (Fabr.)
			Oncocephalus sp.
			Acasthaspis quinquespinosa
			Androclus pictus
		Gerrididae	*Gerris nepalensis* (Dist.)
		Pyrrhocoridae	*Dysdercus similis* (Freeman)
			Antilochus coqueberti (Fabr.)
		Coreidae	*Cletus signatus* (Dallas.)
			Leptocorisa acuta (Thunb.)
			(*Varicornis* F.)
			Leptocorisa augur (Fabr.)
			Petalocnemis sp.
		Pentatomidae	*Bagrada hilaris* (Burm.)
			Agonoscelis nubila (Fabr.)
			Cyclopelta siccifoli.. (Westw.)

HEMIPTERAN INSECTS FOUND IN SAUGAR DIVISION

Locality	Habit
Grass, herbage and other pliage.	Feed indiscriminately.
Collected from the fields on *Acacia arabica* (babul).	A mutual relationship has been observed between membracids and ants. The ants stroke the membracids with their antennae, where upon they exude a liquid from the rectractile anal tube.
Observed on the plants in the hilly areas.	
Collected from thorny *Capparis*.	Larvae and adults mimic the thorns most effectively.
Collected from the grasses in the fields.	Secrete a quantity of fluids in the form of bubbles in the immature stage. These bubbles conceal the insect. This may be a protective device.
Found on the malvaceous plants in the fields.	The female has a mass of white mealy wax on the plants. Eggs are deposited in the wax. The larvae suck the plant.
Collected from the fields and gardens.	Predacious in habit.
Found in slow moving or still water.	Feeds mainly on dead insects or those floating there accidently.
Collected from cotton and other plants of Malvaceae family.	A serious pest of cotton and *Hibiscus*.
Found in dense vegetation.	Feeds on wide range fo insects.
Found in the fields.	Feeds on crop plants.
Found in the fields.	Injuring the seeds of rice and millets.
Brinjal.	
Wide spread and abundant in the fields	Feeds upon rabi cruciferous plants.
Found on field crops.	
Found in fields.	Feeds on *Beautea monosperma* plants.

Sub order	Super family	Family	Insect species
		Pentatomidae	*Dorpius indicus*
			Codophila macculicollis
			Erthesina fullo
		Lygaeidae	*Spilostethus pandurus* (Scop.)
			Graptostethus maculatus (Dall.)
			Aspilocoryphus guttiger (Dall.)
			Oxycarenus laetus (Kirby.)
			Lygaeus civilis (Wolff.)
	Cryptocerata (Division)	Belostomatidae	*Sphaerodema rusticum* (Fabr.)
			Sphaerodema annulatum (Fabr.)
		Nepidae	*Ranatra sordidula* (Dohrn.)
			Laccotrephes sps.
		Notonectidae	*Enithares* sp.

Locality	Habit
Mango plants.	
Collected from the fields.	*Calotropis* plants.
On low herbage.	
Collected form the fields.	
Common through out the cotton-growing area.	Dusky bug of the cotton; and lady's finger plants.
Collected from the fields.	Frequents *Calotropis* (akh) and other plants of the family.
Found in the still water of the ponds.	The eggs are usually borne on the elytra of the males.
	Feeds upon small fish, tadpoles, young frogs and insects.
Fresh water ponds.	Can move two halves of the respiratory tube at Will.
Found in ponds.	

INSECT FAUNA OF SAUGAR DIVISION — II. LEPIDOPTERA

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Lepidopteran insects, are of great economic importance. Obviously, the insects mentioned in Table I belonging to different families have been collected and identified.

ACKNOWLEDGEMENTS

The author is thankful to Mr. D. P. Agrawal, and Dr. U. S. Gupta for helping in the collection of insects, and also to the Director Commonwealth Institute of Entomology (British Museum, Natural History, London) for the identification of insects.

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TABLE I : LEPIDOPTERAN INSECTS FOUND IN SA GAR D

Sub order	Super family	Family	Insect species
Ditrysia			
	Pyralidoidea	Pyralididae	*Epipagis cancellalis* (Zell.)
			Hapalia albicostalis (Swinh.)
	Papilionoidea	Nymphalidae	*Euploea core* (Cramer)
			Danais chrysippus (Linn.)
		Pieridae	*Delias eucharis* (Drury)
		Papilionidae	*Papilip demolius* (Linn.)
	Geometroidea	Geometridae	*Semiothisa eleonora* (Stoll.)
			Thalassodes sps.
	Noctuoidea	Amatidae (Syntomidae)	*Syntomis cyssea* (Cram.)
		Noctuidae (Agrotidae)	*Grammodes Stolida* (F.)
			Risoba obstructa (Moore)
			Plecoptera reflexa (Gr.)
			Polytela gloriosae (Fabr.)
		Hypsidae	*Digama hearseyana* (Moore)

GAR DIVISION

Locality	Habit
Found flying in fields and gardens.	Larvae feed on dry and decaying leaves and vegetable material.
Found in the vegetation of hill areas.	Larvae are borer in plants, often in roots.
Found in fields.	The food plants are the common oleander *Cryptolepis pauciflora, Ficus indica, Ficus glomerata.*
Found in fields.	Larvae feed on *Calotropis* and various Asclepiads.
Found in the plain areas.	Lays eggs in rows. The larva feeds on the mistletoe (*Loranthus*) growing on trees.
Common through out the plains, and occur up to moderate elevations.	Larva feeds on the plants of Rutaceae family (Bael, Ber lime, orange etc.).
Found in fields.	Larvae resemble the twigs or thicker veins of leaves, pest of fruit and shade trees.
Found in gardens and fields.	Larva feeds upon the leaves of litchi and maize.
Found in gardens in the plains.	Feeds on mango leaves, sweet potato and oats.
Found in fields.	Larvae feed on Rice plants.
Found in fields and in thick vegetation.	Food plant — *Quisqualis indica.*
Found in long grass near sissoo trees.	Feeds on Sissoo.
Found in gardens.	Larvae feed upon the leaves of Amaryllids.
Common through out the hills and forest areas.	Feeds upon Sann Hemp *(Crotalaria juncea)* and wild *Crotolaria* larvae march in columns each being headed by a leader.

INSECT FAUNA OF SAUGAR DIVISION — III COLEOPTERA

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Coleopttran insects are known to cause immense loss to men. Obviously a survey of these insects in the Saugar division has been made and insects included in Table I and belonging to different families have been collected and identified.

ACKNOWLEDGEMENTS

The autohr is thankful to Dr. P. K. Shrivastava for the help in the collection of insects, and to the Director, Commonwealth Institute of Entomology (British Museum, Natural History, London) for their identification.

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Table 1 INSECT FAUNA OF SAUGAR DIVISION — III CO

Sub Order	Super family	Family	Insect species
Adephaga			
		Paussidae	*Platyrhopalus denticornis* (Don.)
		Carabidae	*Scarites mahratta* (Andr.)
			Harpaglossus opacus (Chd.)
			Omphra pilosa (Kulg.)
			Chlaenius nitidicollis (Dej.)
			Chlaenius quadricolor (01.)
			Pheropsophus lissoderus (Chd.)
		Dytiscidae	*Cybister limbatus* (F.)
			Eretes sticticus (L.)
			Sandracottus dejeani (Aubi)
			Hydaticus vittatus (F.)
		Gyrinidae	*Dineutes indicus* (Aube)
Polyphaga			
	Hydrophiloidea	Hydrophilidae	*Sternolophus decens* (Zaitz.)
	Scarabaeoidea	Hybosoridae	*Hybosorus orientalis* (Westw)
		Scarabaeidae	*Onthophagus gazella* (F)
		Rutelinae	*Rhinyptia indica* (Burm.)
			Anomala sp.
		Cetoniinae	*Chiloba acuta* (Wiede)
	Cucujoidea (Section Clavicornia)	Coccinellidae	*Anthracophora crucifera* (01)
			Menochilus sexmaculatus (F.)

III COLEOPTERA

Locality	Habit
Found walking on the soil.	Found in ants' nest. Secrete a liquid which is irritant to human skin.
Found in fields.	Carnivorous in habit, a few have been recorded as devouring cereals and the seeds of the plants.
Found in fields.	
Found in fields.	
Found in fields.	
Found in fields.	
Found in ponds and lakes.	The larvae feed on various aquatic animals.
Aquatic in larval and imaginal instars.	Feeds on *Culex* larva.
Abundant in wells & tanks.	
Found in tanks,	
Surface of tanks and streams.	Larva is predacious on other aquatic insects.
Found in demp marshy places or among vegetable refuse.	Adults live upon decomposing vegetation.
Found among vegetation.	Appearance is almost that of a Tenebrionid.
Common in ths plains.	Feeds on dead insects, drug etc.
Larvae live in the soil in forests and hills.	Larvae feed on the roots of rice, bajra and other cereals.
Found in plains.	Adult destructive to plants in the gardens, larvae feed on roots.
Found some times in abundance on flowers of cereals.	Feed on the anthers and stigma of juar, rice and millets.
Wide spread on plains.	Feeds on cruciferous plants.

Sub Order	Super family	Family	Insect species
			Illeis indica (Timberlake)
			Epilachna ocellata (Redt).
	(Section. Heteromera)	Tenebrionidae	*Opatroides punctulatus* (Brull.)
			Rhytinota sp.
			Gonocephalum catenulatum (Frm.)
			Gonocephalum civicum (Kas.)
		Meloidae	*Epicauta waterhousei* (Haag.)
			Sybaris testaceus (F)
			Psalydolytta rouxi (Lap.)
			Mylabris medioinsignata (Pic)
			Cyaneolytta coerulea (Lueck)
	Chrysomeloidea	Cerambycidae	*Apiocephalus lichanecus* (Gah.)
			Diorthus simplex (White).
		Chrysomelidae	*Sagra nigrita* (01).
			Sagra purpurea (Licht).
			Galerucella birmanica (Jac.)
			Corynodes peregrinus (Hbst).
			Aulacophora foveicollis (Kust).

Locality	Habit
Found in fields.	Feeds on the flowering plants of cultivated crops.
Found in fields and vegetable fields.	Found on bitter ground and other vegetables.
Live in shade in the dense indigo crops.	Feeds on fallen dry leaves.
Found in gardens & fields.	Feeds on flowers and floral buds.
Woody vegetation. Common and Wide spread sps.	Destroys woods. Larvae bore for the most part into the wood of tree, mango etc.
Lives in the swelling on the stems.	Cause gall like hypertrophy of the wood, larvae found in the roots of the trees.
Larva-free, exposed or in under ground parts of plants.	Destructive in its larval and imaginal stages to waternut or Singhara crop destroying the leaves.
Abundant in plains.	Feeds on Ak and other wild plants, Feeds on leaves.
Found on cucurbitaceous plants.	Feeds on pumpkin leaves.

OBSERVATIONS ON THE MORPHOLOGY OF *AULACOPHORA* — A PEST OF PLANTS OF CUCURBITACEAE FAMILY

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INTRODUCTION

The genus *Aulacophora* is distributed practically all over India and is a pest which feeds on and destroy a large number of plants belonging to the family Cucurbitaceae. Maulik (1936) in the fauna of British India, has described twenty two species of *Aulacophora* and has divided them into three series (i) those with orange body and elytra and black ventral surface (ii) those with black elytra and brown or orange head and (iii) those with elytra having more than one colour. In the present work, one representative of each of these three series, the first of the series being represented by *A. foveicollis* Luc., the second by *A. atripennis* Fab., and the third by *A. cincta* Fab., has been taken and a comparative morphology of these three has been described to fill in the gap in our knowledge of the morphology of these species and also that of the sub family — Galerucinae, to which it belongs.

MATERIALS AND METHODS

Specimens of *A. foveicollis* and *A. atripennis* were collected locally from Sagar and its neighbourhood, from different cultivated plants of the family Cucurbitaceae. Specimens of *A. cincta* were collected from Sathenpelli (Andhra State : South India). They were fed on the leaves of *Trichosanthes anguina* (Snake gourd) which is their favourite food. For dissection both fresh as well as preserved material was employed.

OBSERVATIONS

External Morphology :

Aulacophora foveicollis Luc.. is one of the commonest species of *Aulacophora* found in Northern India. It is a small beetle 6—8 mm in length. On the dorsal side, it is deep orange red while the ventral side is black except the head, prothorax and the hindermost end of the abdomen which are orange red. The walking legs are also orange red.

Aulacophora atripennis Fab., is also commonly found in Northern India, but is somewhat smaller in size than *A. foveicollis*, being 5.5 to 6.5 mm in length. Dorsally, the body is orange red except the elytra which are black. Ventrally, it is black except the head, prothorax and the hinder extremity of the last sternite which are orange red. The walking legs are of a lighter orange shade.

Aulacophora cincta Fab., is generally not found in Northern India, but is common in Southern India . It is the longest

of the three species under consideration and is 7 to 8.5 mm in length. Dorsally, the body and elytra are yellowish brown, but the elytra show black marginal and sutural stripes. The walking legs as well as the ventral surface of the body, however, are pale yellowish brown.

Secondary Sexual Characters :

All the three species show well-marked secondary sexual characters. These affect the size of the insects, the antennae, the pygidium (7th tergite), and the last visible sternite. These may be summarised as follows :—

(1) As a rule males are smaller in size than females.

(2) In *A. foveicollis* and *A. atripennis* the first segment of the antenna in the male is the thickest, but in the male of *A. cincta* the fourth segment is thickest (Fig. 1 A B C D E F).

(3) In male the pygidium is obtuse behind while in female it is pointed (2 A B). In *A. cincta,* however, the pygidium in the female is somewhat less sharply pointed than in the female of the other two species.

(4) In the male the last externally visible sternite (definitive 7th sternite) is divided into three distinct lobes distally; of these the lateral lobes appear conical while the median lobe is rectangular. The median lobe shows a shallow median

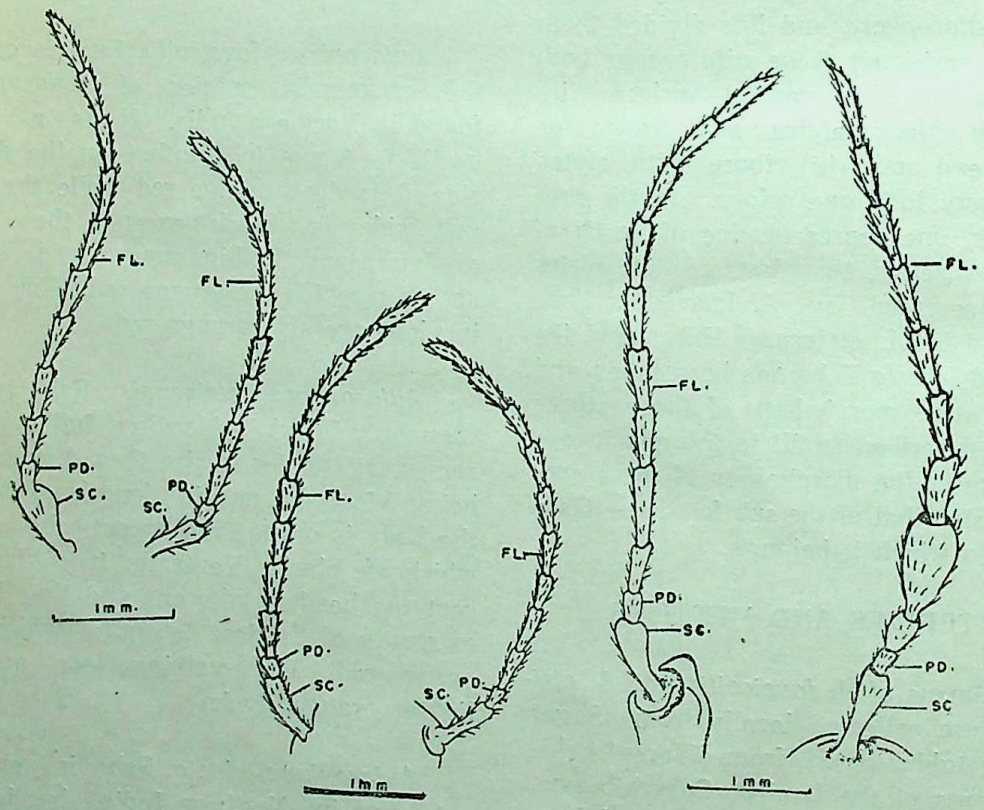

FIG. 1 :— A, B, C, D, E, F

groove on its ventral side and the edge of the groove are provided with thick hairy covering; the median groove, however, shows slight differences in the three species as shown in (2 A B C and D E F).

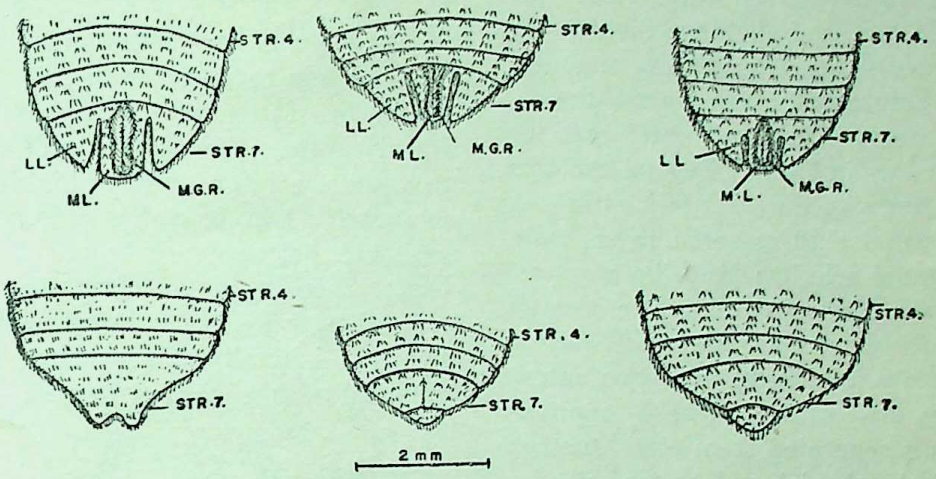

FIG. 2 :— A, B, C, D, E, F

In the female of *A. foveicollis* the last visible sternite is notched behind (Fig. 2 B); in the female of *A. atripennis* and *A. cincta*, however, the sternite shows only a shallow concavity. (Fig. 2 D and F).

The Head :

The head is oblong and prognathous. the prothorax by a small membranous cervix or neck. The dorsal part of the head is mainly occupied by the cranium and is separated off from the posteriorly situated occipital area by a occipital suture (Fig. 3. A and B). The cranium can be distinguished into three regions — (i) Epicranium, (ii) Cranium proper and (iii) Vertex. The epicranium forms a small postero-dorsal portion between the cranium and the occipital area. The cranium proper forms the largest portion of the head but is not divided into left and right halves or parietals by an epicranial suture as in some other insects. The vertex forms the anterior-most portion of the cranium and is somewhat raised posteriorly. The cranium is highly chitinised, punctate and smooth. Anteriorly the cranium is somewhat depressed and shows a pair of ocular areas

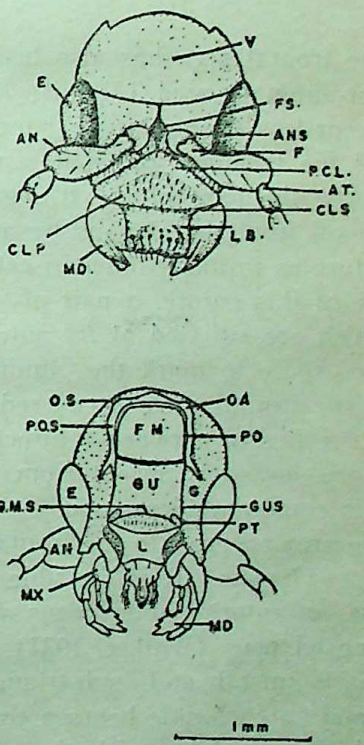

FIG. 3 :— A, B

on the sides which are occupied by the compound eyes. In between the two ocular areas the space is divided into a pair of interocular areas by an inverted Y-shaped ridge known as the frontal suture. The stem of the frontal suture arises from the vertex and after some distance divides into the two limbs of the Y. The two limbs of the frontal suture serve to separate the inter-ocular areas from the frontal area or frons which lies in front. Beyond the tips of the two limbs of the frontal suture a pair of antennal sutures serve to separate off the antennal sclerites from the cranium. The two limbs of the frontal suture, though they approach closely the antennal sutures, do not actually join them. The two antennal sclerites are rather closely approximated, being separated from one another by a small rhomboidal and somewhat depressed posterior portion of the frontal area.

The frontal area has also been named as inter-antennal area (Maulik, 1936). It is more or less triangular in shape with the apex of the triangle directed backwards. Anteriorly, the base of the triangle is not marked off from the clypeus by an epistomal suture as in many other insects. In the absence of this suture, a pair of tentorial pits which are situated at *its* anterolateral margins, serve to mark the limits of *its* area. The frontal area is covered with a thick covering of forwardly directed hairs *which* are. however, absent from the apex *which* is somewhat depressed.

The area anterior to the frontal area is known as clypeus. It is divisible into two portions, an anterior anteclypeus and a posterior postclypeus (Walker, 1931). The postclypeus is smooth and sub-triangular in shape and on each side bears a convex process which articulates with the ginglymus of the corresponding mandible. The anteclypeus is more or less triangular in shape with its apex directed behind and the broad somewhat convex base directed forward. Unlike the postclypeus the anteclypeus is covered with small hairs.

In front of the anteclypeus lies the more or less rectangular labrum (3. C). It is attached to the anteclypeus by a clypeolabral suture. The labrum is divisible into two parts, a large *anterior* highly chitinised *anterior* labrum and a narrower membranous posterior labrum (Crampton, 1932). The posterior labrum is normally covered over by the anterior edge of the clypeus. Laterally, the posterior labrum is provided with a pair of curved, chitinous

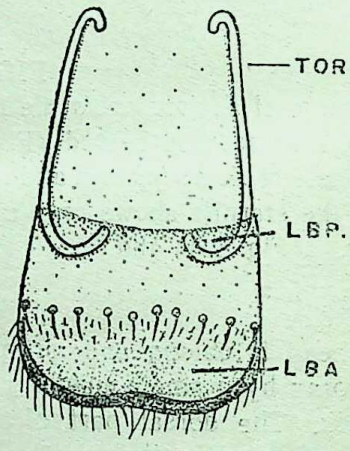

FIG. 3 :— C

rods known as 'tormae' or chitinised epipharynx (Revnay, 1928) which are continued backwards upto the oesophagus. These rods support the epipharynx, pharynx and the anterior part of the oesophagus. the middle. Dorsally, the surface of the anterior labrum is punctate and hairy, the hair being specially prominent along its free edge. Ventrally, the anterior labrum forms the anterior epipharynx and is provided with small hairs.

Ventrally the head presents a flattened appearance and towards its posterior side shows a large aperture known as the foramen magnum. The foramen magnum is surrounded on the dorsal and lateral sides by a narrow sclerite known as the post-occiput and a post-occipital suture to which the neck membrane is attached. In *Aulacophora* the post-occiput is extremely narrow and in the region of the foramen magnum appears as an inflection of the post-occipital suture. The lower ends of the post-occipital sutures are greatly elongated and their ends are marked by the posterior tentorial pits, but the post-occiput itself never extends right upto these pits. Just external to the post-occipital suture is a horse-shoe-shaped sclerite known as the occipital(s) arch which is marked off from the rest of the epicranium by a well-marked occipital suture. The occipital arch is divisible into a dorsal part known as the occiput, and a pair of small laterally directed processes above the gena.

On the ventral side of the head, in front of the foramen magnum, a gula is present as in other prognathous insects. In *Aulacophora* the gula is well developed and is in the form of a broad, more or less rectangular plate-like structure which extends from the hinder boundary of the foramen magnum upto the level of the posterior tentorial pits where it is separated from the submentum of the labium by a gulo-mental suture. Laterally, the gula is bounded on either side by a gular suture which is a forward prolongation of the post-occipital suture.

The lateral parts of the cranium beneath the eyes are known as the genae. The subgenal sutures, which in several insects are situated on the sides of the head close to the lateral cranial wall, are absent.

The Tentorium :

In pterygote insects there is an endoskeletal structure in the head known as the tentorium, and typically it consists of two pairs of cuticular invaginations which arise from the anterior and posterior tentorial pits and are known as the anterior and posterior tentorial arms respectively. In *Aulacophora* the tentorium is very poorly developed. The anterior arms are practically absent and the posterior arms are rudimentary. A tentorial bridge between the posterior arms is not developed.

The Antennae :

The head bears a pair of slender elongated and filiform antennae (1. A B C D E and F). The base of each antenna is lodged in an antennal sclerite which is situated on the outer margin of the frons. Basally the two antennae lie close together. The antennae consist of eleven segments and are covered with fine hairs. The first segment of the antenna or scape is the longest and the second segment or pedicel is the smallest. Segments third to ninth are more or less similar in size and shape and each is in the form of a cone-like structure with the narrow basal part directed proximally. The tenth segment is more or less cylindrical. The eleventh or terminal segment is somewhat spindle shaped and is longer than all the other segments of the antenna except the first and terminates bluntly. The antennae if turned backwards reach upto the first abdominal segment. The length of the antenna in the male and female in the three species is as follows :—

Species	Male	Female
A. foveicollis	4.5—5 mm	4—4.5 mm
A. atripennis	4 4.5 mm	4—4.5 mm
A. cincta	5.5—6.5 mm	5—6 mm

The differences in the antennae of the male and the female of *Aulacophora* have been already dealt with (vide *supra*).

The Mandibles :

The mandibles are of the biting type. Each mandible is a thick strong structure with a broad tri-angular base (Fig. 3. D).

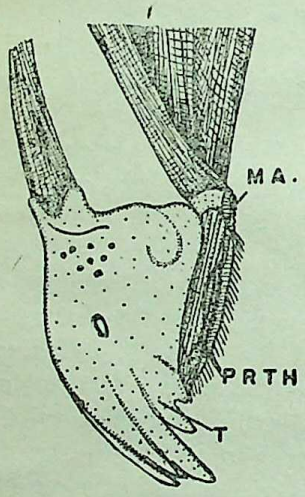

FIG. 3 :— D

Its dorsal surface is more highly cuticularised than the ventral one. Its inner or mesial surface forms the cutting blade and is differentiated into a distal toothed incisor lobe and a proximal molar lobe. The incisor lobe is larger than the molar lobe and is provided with six highly chitinised teeth which appear almost black in colour. Of these six teeth, the third is the longest and the fifth and sixth are much smaller than the others in all the three species. The basal or molar lobe appears as a narrow elongated area along the mesial edge of the mandible and on its dorsal side it is provided with a masticatory surface composed of a series of closely packed parallel ridges separated by grooves. In addition, there is a narrow, elongated, flexible hairy plate-like structure on the ventral side of the molar lobe of the mandible known as the prostheca. It extends backwards from the last or sixth tooth almost upto the hinder end where it leaves a small portion of the molar area exposed when the mandible is examined from the ventral side.

The outer margin of the mandible is convex and smooth. Each mandible articulates by means of the outer edge of its triangular base with the head by means of two articulations — a ginglymus and a condyle. The ginglymus is in the form of a concavity which articulates with a corresponding convexity of the post clypeus. The condyle is in the form of a small rounded head which fits into a socket placed at the lower end of the gena. There is a large apodeme attached at the inner angle of the base of the mandible for the attachment of its powerful adductor muscles. The outer angle of the mandible also gives rise to an apodeme, but it is much smaller and the abductor muscles of the mandibles are attached to it.

The Maxillae :

The maxillae form the second pair of mouth appendages. Each maxilla consists

of the following parts : cardo, stipes, maxillary palp and lacinia (Fig. 4 A and B). The cardo is in the form of an elongated cone-like structure which articulates with the head by its narrow proximal end by means of a condyle which fits into a concavity situated at the geno-submental angle. The stipes is a large, more or less flattened segment and is divided by a longitudinal ridge into an outer and an inner portion known as the parastipes and eustipes respectively. The maxillary palp is four jointed and is attached to the eustipes by means of a palpifer which appears as a flattened area on the outer surface of the eustipes. In the maxillary palp the first

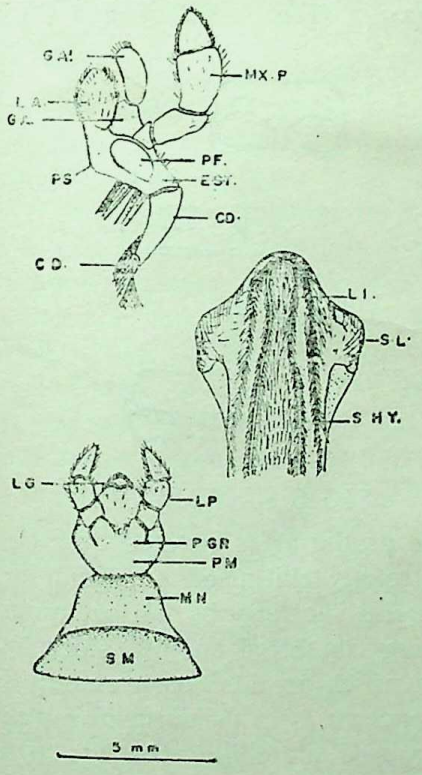

FIG. 4 :— A, B, C

segment is the smallest while the third is largest. The fourth or terminal segment is comparatively small and ends bluntly. The maxillary palp is provided with numerous small hairs. The galea and lacinia are in the form of small flattened sclerites which project forward from the distal end of the eustipes. The galea is the outer element and is in the form of a curved elongated structure. It is divided into two segments, a proximal somewhat broader basigalea and a distal, narrower, curved distogalea. The latter is fringed with a dense mass of long hairs. The lacinia which lies internal to and partly covered over by the galea in the natural position, is in the form of a more or less triangular piece with the apex directed forwards. Its sides are fringed with long hairs and its surface is also hairy.

The Labium :

The labium forms the anteriormost part of the head on the ventral side. It is marked off from the anterior edge of the gula by a transversely placed gulomental suture. The labium is divisible into an anterior and a posterior portion known as the pre-labium and post-labium respectively, the two being separated by the labial suture (4. B). The post-labium is divisible into two portions, a posterior submentum and an anterior mentum. The submentum is sub-triangular in shape with the broad base directed towards the gula. On the ventral surface it is provided with a row of long, stiff, bristles which are probably sensory in nature. The mentum is more or less rectangular in shape and provided with some hairs on the ventral surface. The prelabium is represented by the pre-mentum which is movably articulated with the anterior edge of the mentum by means of the labial suture. From the ventral surface of the mentum near its base arise two large,

closely approximated protuberances known as the palpigers, to which the labial palps are attached. Each labial palp consists of three segments, of which the first or the basal segment is the smallest while the second is large and well developed; the last or terminal segment is narrower and bluntly pointed. The labial palps are covered with small hairs. The anteriormost part of the labium is formed by a small triangular piece known as the ligula which is densely covered with small hairs. Glossa and paraglossa are absent.

The Hypopharynx :

The hypopharynx is a median structure which forms the floor of the buccal cavity (4.C). It is fused with the dorsal region of the labium and extends from the ligula in front upto the submentum. The anterior portion of the hypopharynx is produced laterally into a pair of triangular lobes called the superlinguae. The median portion or lingua presents a median depression which is continued behind into the mouth. In front of the mouth opening this depression forms the floor of a special pre-oral food chamber or cibarium which is situated beneath the opposing epipharyngeal wall of the clypeus. Behind the superlinguae, the sides of the hypopharynx are flanked by a pair of slender rod like sclerites which have been called the hypopharyngeal bars (Dorsey, 1943), and they constitute the suspensoria of the hypopharynx. These suspensorial sclerites enter the lateral angles of the mouth and finally terminate in the wall of the stomodaeum.

The Cervicum or Neck Region :

The cervicum in *Aulacophora* is in the form of a flexible membranous structure joining the head and thorax; there are no cervical sclerites on this membrane.

The Thorax :

The thorax, as usual in all insects, is composed of three segments — prothorax, mesothorax and metathorax. The prothorax is free, but the meso — and meta-thoracic segments are closely united to form the so-called ptero-thorax. The prothorax bears ventrally the first pair of walking legs; the meso — and meta-thorax not only bear the second and third walking legs on the ventral side but also the paired wings on their dorsal side.

Prothorax : (Fig. 5 A B C and D) :

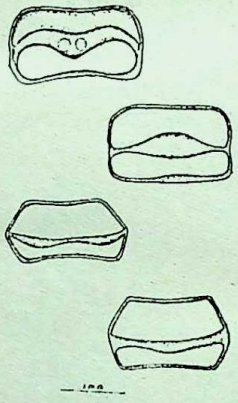

FIG 5 :— A, B, C, D

The prothorax is covered over dorsally by a strongly chitinised pronotum or protergum and ventrally by the eusternum, the two being connected on the sides by the pleuron which are also hard and chitinised. The pronotum is in the form of a quadrangular arched plate-like structure which is much broader than long. The margin of the pronotum is slightly reflected all round towards the ventral side. Dorsally the pronotum is divided transversely into three

areas; the anterior and posterior areas are somewhat raised and are separated off from one another by a narrow, middle area which is somewhat depressed. In the male *A. foveicollis,* however, the posterior area is deeply notched in front by a triangular backward prolongation of the middle area and the latter shows a pair of small rounded elevations on either side of the middle line. In the female *A. foveicollis,* and in both sexes of *A. atripennis* and *A. cincta,* the middle area is devoid of any raised areas (5. A B C and D).

The sides of the prothorax are formed by a pleuron on either side. Each pleuron is in the form of a highly chitinised more or less triangular plate-like structure which articulates by its broad base with the pronotum. The apex of the pleuron is directed downwards and shows a concavity which surrounds the base of the coxa of the first leg on the dorsal anterior and posterior sides. The anterior edge in front of the coxa is produced ventrally into a small but well defined process known as the trochantin and bears the anterior trochantinal articulation of the coxa. Running upwards along the sides of the pleuron from the coxal articulation there is a well-defined pleural suture which, however, does not extend upto the dorsal margin of the pleuron. The outer wall of the pleuron along the pleural suture is inflected inwards to form an internal pleural ridge. The pleural ridge serves to divide incompletely the pleuron into an anterior episternum and posterior epimeron. The epimeron shows a shallow vertical depression on its surface. The ventral wall of the prothorax is formed by the eusternum which is divisible by a transversely placed sternal suture into an anterior basi-sternum and a posterior sternellum (or furca sternum). The basi-sternum is in the form of a well developed, broad, chitinised plate-like structure and posteriorly it is produced into a small triangular process in the mid-ventral line known as the sternal lobe (6. B). The sternellum is in the form of a comparatively small membranous structure situated behind the sternal lobe and surrounds the base of the coxa of the first walking leg on the ventral side. The sternellum, ventrally shows a pair of shallow furcal pits, which are produced internally into a pair of small furcal processes (Fig. 6. A and B).

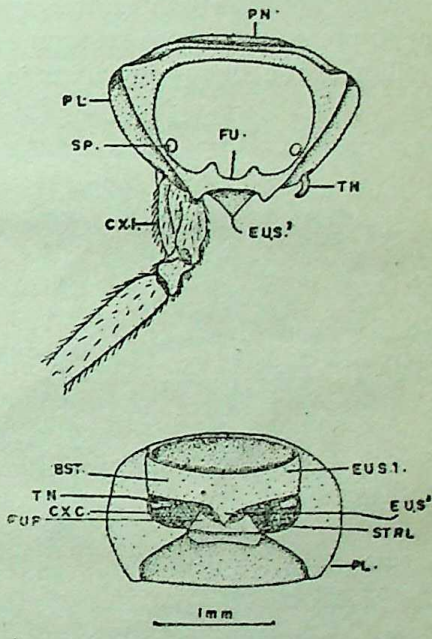

FIG. 6 :— A, B

Mesothorax (Fig. 7 A B C):

The mesothorax forms the smallest segment of the thorax. The tergal plate or meso-notum is divisible into an anterior wing bearing portion known as the alinotum and a posterior phragma bearing portion known as the phragmanotum. The phragma of the prothoracic notum is fused

with the anterior side of the notum of the mesothorax, and similarly the phragma of the mesothorax is fused with the anterior side of the notum of metathorax.

In *A. foveicollis* the phragma of the prothorax which is fused with the notum of the mesothorax is not well developed and is represented by the slightly inflected anterior edge of the mesonotum. Just behind the anterior edge of the notum there is a poorly developed antecostal suture and the narrow strip in front of it represents the acrotergite. Behind the antecostal suture the post costal portion of the alinotum is divided transversely into three areas namely meso-prescutum, meso-scutum and meso-scutellum. The meso-prescutum is a more or less flattened rectangular plate-like structure and is produced on either side into a pair of small projections known as the anterior and posterior wing processes. It also shows a prominent mid-dorsal ridge. Behind the meso-prescutum lies the triangular meso-scutellum with its bluntly pointed apex directed backwards. It is welded over a broad and highly chitinous plate known as the meso-scutum which is fused with the hinder edge of the meso-prescutum. Thus from the dorsal side only the sides of the meso-scutum are seen as its median portion is covered over by the meso scutellum. The lateral walls of the mesothorax are formed by the pleura which are represented on either side by a pair of highly chitnised plates lying side by side

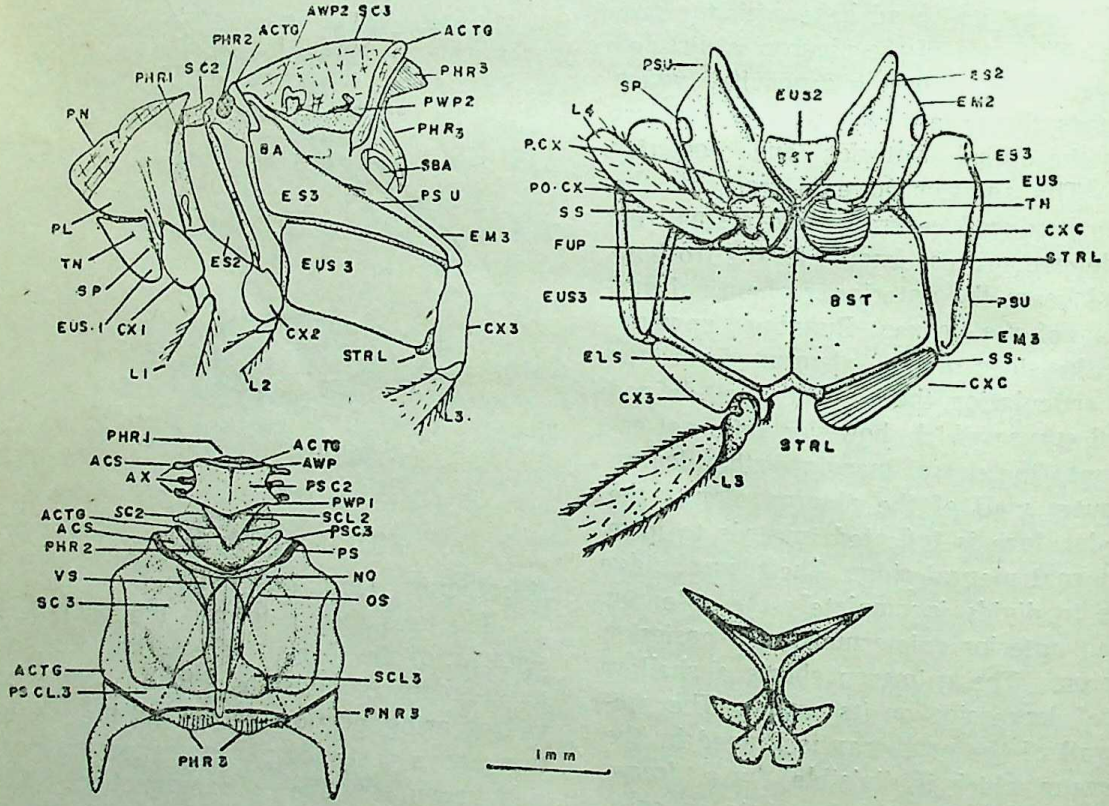

FIG. 7 :— A, B, C, D

and separated from one another by a longitudinal pleural suture. The anterior plate is known as the episternum and the posterior one as the epimeron. Dorsally, the episternum articulates with the meso prescutum while the epimeron artuculates with the epimeron artuculates with the meso-scutum. Ventrally, the episternum articulates with the meso eusternum while the epimeron articulates with the basisternum of the metathorax. The ventral basal portion of the episternum forms the precoxale and a small portion of the corresponding basal portion of the epimeron forms the post-coxale. The pre — and post-coxales form part of the boundary of the coxal, cavity with which the coxa of the second leg articulates. The pre-coxale also gives off anteriorly a small process known as the tronchantin which is, however, less developed than that of the prothorax. The ventral wall of the meso-thorax is formed by a comparativtly small eusternum. It is divided transversely by a meso-sternal suture into two portions, a comparatively small anterior meso-basisternum and a much smaller posterior portion known as the meso-sternellum. The meso-basisternum is in the form of a broad triangular highly chitinised plate with the broad base directed forwards; its narrow posterior portion forming the apex is known as the sternal process. The meso-sternellum is membranous and triangular in shape, but unlike the meso-basisternum, in this case the apex of the triangle is directed forward. Posteriorly, the meso-sternellum is provided with a pair of furcal pits and it also shows a faint mid-ventral suture. The meso-sternellum is produced inwards into a Y-shaped process known as the meso-furca for the attachment of muscles.

Metathorax (Fig. 7 A B C and D) :

The metathorax forms the largest segment of the thorax. As in the meso-thorax the tergal plate or notum is divisible into an anterior alinotum and a posterior phragmanotum (or meta post-scutellum). The phragma of the mesonotum gets fused with the anterior edge of the meta-notum so that the metanotum shows a phragma both anteriorly as well as posteriorly. As in mesothorax, the alinotum is divided by a transversely placed antecostal suture into an anterior extremely narrow strip called the pre-acrotergite and a large posterior postcostal portion. The antecostal ridge and the pre-acrotergite are better developed in the metanotum than in the mesonotum. As in mesothorax, the postcostal portion of the alinotum is divided by means of sutures into three portions called the meta-prescutum, metascutum and meta-scutellum. The meta-prescutum is represented by a comparatively narrow transversely elongated plate which somewhat slopes forward. Posteriorly it is separated from the metascutum by a prescutal suture. The metascutum forms the greater part of the postcostal portion of the alinotum and is in the form of a large highly chitinised plate which is arched from side to side. In the mid-dorsal line, the metascutum is covered over by a more or less triangular plate called the metascutellum which is separated from the former by an inverted V-shaped called the scuto-scutellar suture. The metascutellum is attached to the anterior margin of the phragmanotum by its broad base, while its apex extends almost upto the posterior margin of the meta-prescutum. The surface of the metascutum is also marked by a pair of sutures on either side of the metascutellum which are known

as the convergent sutures (or notaulices) and the oblique sutures (7 B). The convergent sutures arise from the antero-lateral borders of the scutum and after running for some distance close behind the prescutal suture, turn backward to join the sides of the scuto-scutellar suture some distance behind the apex of the meta-scutellum. The oblique sutures lie some distance behind the convergent sutures and also join the sides of the scuto-scutellar suture. The oblique suture serves to divide the metascutum into a small anterior somewhat depressed area situated between the oblique suture and the convergent suture and a much larger convex posterior area. Laterally, on each side the metascutum is produced into an anterior and a posterior wing process. In between these two processes four small sclerites known as the axillaries are attached to the margin of the metascutum for the attachment of the meta-thoracic wings. The phragmanotum (or meta postscutellum) is divisible into an anterior post-acrotergite and a posterior phragma. The post-acrotergite is in the form of a narrow, band-like chitinous plate extending from side to side behind the metascutum and metascutellum. The posterior phragma is normally overlapped by the articulating membrane behind it and projects behind from the posterior border of the post-acrotergite in the form of a strongly chitinised plate which posteriorly presents a bilobed appearance. On the sides of these lobes, the phragma is produced inwards to form apodemes which project into the body.

As in the mesothorax, the pleuron on each side is divided into two portions, an anterior episternum and a posterior epimeron by a pleural suture, which, however, in this case runs backwards very obliquely (7 A). The antero-dorsal portion of the episternum is produced into a rounded projection which corresponds to the basalare of the other insects and similarly the epimeron is produced dorsally into another process which corresponds to the subalare. The boundary of the coxal cavity with which the coxa of the third leg articulates, is formed mainly by the distal end of the epimeron though the episternum also takes a small part in it. The anterior episternum, however, is not produced into a process corresponding to the trochantin as is found in the pro— and meso—thorax.

The ventral wall of the metathorax is formed by a meta-eusternum and is divided by a meta-sternal suture into two parts, a meta-basisternum and a meta-sternellum (Fig. 7 C). The meta-basisternum forms the main portion of the ventral wall of the thorax. It is divided into a left and a right half by a mid-ventral suture which is often termed as the enigmatic longitudinal suture. The meta-sternellum is in the form of a narrow plate-like structure and shows a pair of furcal pits on its surface. The metasternellum is produced inwards in the body cavity in the form of a large Y-shaped furca for the attachment of the muscles (7 D). The sides of the furca are attached to the apodemes which project into the body from the posterior phragma of the metathorax.

The Walking Legs (Fig. 8 A B) :

Of the three pairs of walking legs, the pro-thoracic legs are smallest while the meta-thoracic legs are longest. Each leg, beginning from the proximal end, consists of the following segments: coxa, trochan-

segments and pre-tarsus ending in a pair of claws. The coxa of the pro- and meso-thoracic legs are sub-oval in shape and are movably articulated with the trochantin of the segment. The coxa of the pro-troracic leg is simple but the coxa of the meso-thoracic leg shows a longitudinal groove along its ventral aspect. The coxa of the meta-thoracic leg is large, transversely flattened and is immovably articulated with the meta-epimeron and meta-eusternum. The trochanter is a small triangular piece joining the coxa to the femur. The femur is long and thick, while the tibia, though also long, is more slender. The arthrodial membrane connecting the tibia and the first tarsal joint, bears a well developed tarsal spur. Of the five segments of the tarsus, the first, second and fifth are elongated cone-like structures with a narrow proximal and a broader distal end. The third segment is small, and bilobed distally. The fourth segment is very small and horse-shoe shaped, and the proximal end of the fifth segment fits in the gap of the horse-shoe. The pre-tarsus arises from the end of the tarsus by a membranous base, upon which is supported a pair of bifid claws. Each claw is articulated dorsally with a small median process or unguifer of the fifth tarsal joint. On the ventral surface of the pre-tarsus is a median basal plate called the unguitractor. In addition, beneath the base of the claws, there are a pair of lateral plates known as the auxiliae. Each claw is a hollow structure and shows two pointed processes, a large outer claw lobe and a smaller inner claw lobe.

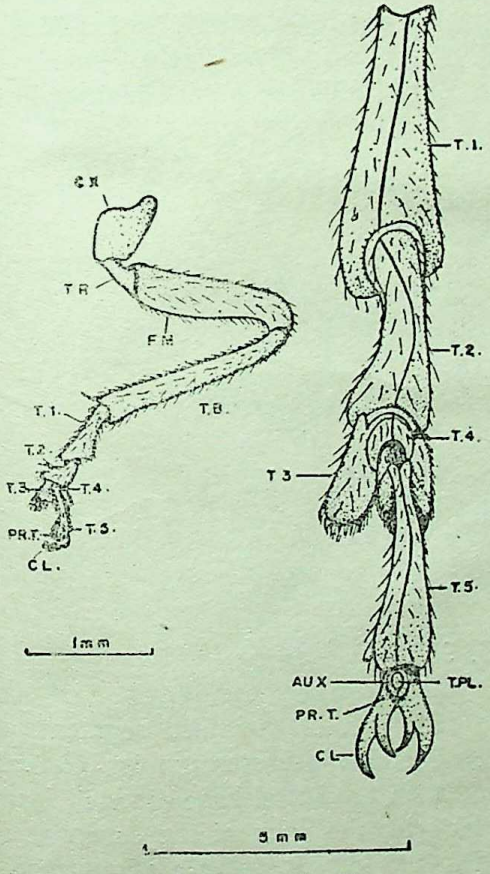

FIG: 8 :— A, B

The following chart shows the comparative length of the walking legs in the three species of *Aulacophora* :—

Species	Length of fore- leg. Ist leg.	Length of middle leg. IInd leg.	Length of hind leg. IIIrd leg.
A. foveicollis	5 mm	5.5 mm	7 mm
A. atripennis	5 mm	5.5 mm	6 mm
A. cincta	5.5 mm	6.5 mm	7 mm

The Abdomen : The abdomen is composed of ten segments, of which the first seven may be called the pregenital segter, femur, tibia, tarsus consisting of five

ments, eighth and ninth as genital segments and the tenth as the anal segment (Fig. 9). When seen from the dorsal side, seven well developed abdominal terga connected by thin inter-segmental membrane can be seen and they represent the terga of the pregenital segments. Ventrally, only five well-developed sterna can be seen, and these represent the sterna of the 3rd to 7th pregenital segments. The sternum of the first segment is greatly reduced and is represented by a pair of small lateral plates only; the sternum of the second segment is also similarly reduced to a pair of small lateral pieces which are fused with the anterior margin of the sternum of the third segment (Fig. 9). Laterally, the terga and the sterna are joined with each other by soft chitinous pleura bearing the seven pairs of respiratory spiracles.

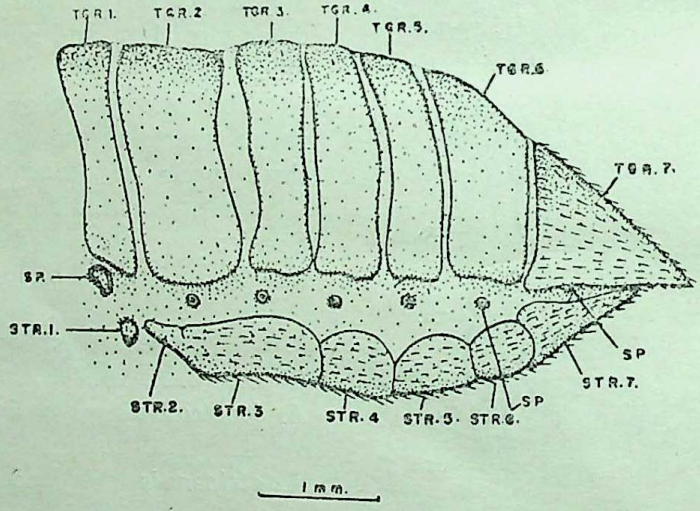

FIG. 9

The tergum of the first segment is the narrowest of all terga and is attached to the meta-postscutellum anteriorly. The second tergum is broader than the rest and the seventh tergum is called the pygidium. The latter is triangular in shape with the apex directed backwards. The pygidium shows sexual dimorphism and this has been described before. The sternum of the first and second abdominal segments are greatly reduced so that the first fully developed sternum belongs to the third segment. It is the lagrest of all the sterna and its anterior margin shows a pair of concavities corresponding to the convex surfaces of the coxa of the third pair of walking legs. The two concavities are separated from one another in the mid-ventral line by a forwardly directed blunt conical process which is situated just behind the sternellum. Anteriorly, the lateral margins of the third sternum are produced on either side into a forwardly directed process and the paired sternal rudiments of the second abdominal segment are fused with them, though the line of fusion is often marked by a suture. The fourth, fifth and sixth abdominal sterna are well deveolped, though they are narrower than that of the third segment. The seventh abdominal sternum is conical in shape with the broad base directed forward. Posteriorly, the apex of the seventh sternum in the female shows a slight concavity in *A. atripennis* and *A. cincta* and a deeper

notch-like groove in *A. foveicollis*. In the male, the apex of the seventh sternum is trilobed and consists of a broad median lobe and a pair of more or less bluntly pointed lateral lobes. The median lobe shows a shallow depression along its mid-ventral surface. In addition, the anterior edge of the seventh sternum is produced inwards into a wide semi-circular flap-like structure which projects upwards and forwards into the body cavity; from its posterior surface a median longitudinal ridge projects backwards and is continued along the mid-dorsal line of the sternum itself. This semi-circular plate serves as an apodeme for the attachment of some of the muscles in the abdomen.

The tergites and sternites of the eighth and ninth segments are hidden by the large tergum and sternum of the seventh segment. The tenth segment is devoid of a distinct tergum or sternum and is represented by a membranous area situated round the anus. The terga as well as the sterna of the eighth and ninth segments differ in the male and the female. In the male, the tergum of the eighth segment is connected with that of the seventh by a wide intersegmental membrane and is in the form of a small strongly chitinised arched plate which is broader in front and somewhat narrower behind. Posteriorly, it shows a deep concavity and the entire posterior margin is turned inwards ventrally for some distance as a strongly chitinised area (Fig. 10.A). The antero-lateral margins of this tergum are produced anteriorly to form strong apodemes for the attachment of the protractor muscles of the

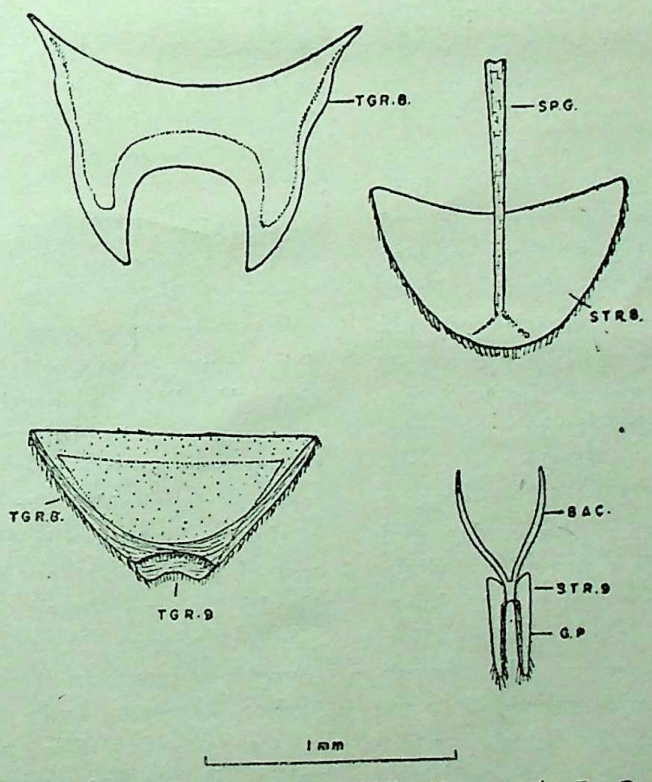

FIG. 10 :— A, B, C, D

aedeagus. A distinct strongly chitinous tergum of the ninth segment is not recognisable and it is represented by a membranous area situated below the preceding tergum. The ventral surface of the tergum of the eighth segment and the membranous tergum of the ninth segment form the roof of the male genital chamber. In the female, the tergite of the eighth segment is bilobed posteriorly. Its posterior lobes and the lateral margins are sclerotised, but the rest of the tergite is membranous (Fig. 10 B). The tergite of the ninth segment is similar to the above, but is much smaller in size. In the normal condition it lies ventral to the tergite of the eighth segment except for the small posterior margin (Fig. 10. B).

In the male, the sternum of the eighth and ninth segments seem to be absent. The male genitalia is represented by a median aedeagus and its ventral processes or struts and the internal sac. In the female, the sternum of the eighth segment is present in the form of a small plate which is notched behind; its posterior and lateral margins are sclerotised but the anterior portion is membranous (Fig. 10 C). From the posterior sclerotised portion of this sternum a long slender rod-like process or spiculum projects forward in the mid-ventral line and extends almost upto the anterior border of the sternite of the sixth segment. The sternum of the ninth segment seems to be absent, but at the hinder end of the segment there is a small, median, strongly sclerotised piece which is prolonged anteriorly into a pair of long, slender, horn-like processes known as the baculi (Tanner, 1927), which are embedded in the ventro-lateral regions of the female genital chamber (Fig. 10 D). A pair of small, unsegmented, elongated processes known as the genital palps project backwards from either side of the median basal piece referred to above and the vulva is situated between these palps. The opposing mesial surfaces of the two genital palps are specially thickened and grooved, so that when apposed together, they enclose between them a narrow channel through which the eggs pass to the outside. The genital palps, the baculi and the median piece from which the latter arise, represent the elements of the female genitalia.

DISCUSSION

I. External Morphology :

The three species of *Aulacophora* described in the present work, show a number of differences in their external morphology. They also differ in several respects from the only other Indian genus *Galerucella* which is included in the subfamily Galerucinae.

Maulik (1936) has described in detail twentytwo species of *Aulacophora* in the *Fauna of British India*, but the present author has come across certain observations which have not been mentioned by him. Maulik has described that the inter-antennal area in *Aulacophora* is hairy, but the present author has noticed that the median rhomboidal area between the base of the two antennae is not hairy, though the rest of the inter-antennal area is hairy. Maulik has mentioned the presence of a median groove in the sternite of the seventh segment in the male. The present author, however, finds that this groove shows specific differences. In *A. foveicollis*, it is more or less awl-shaped with

the point directed forwards; in *A. atripennis* also it is awl-shaped but the point is directed backwards; in *A. cincta,* it is bluntly conical with the apex directed forwards. Hussain and Shah (1926), described the pygidium in *A. abdominalis* as obtuse in the male and pointed in the female. This species, however, was wrongly identified by them, as was pointed out by Maulik (1936) and should have been identified as *A. foveicollis.* The present author's observations on the pygidium of *A. foveicollis* agrees with those of Hussain and Shah in *A. abdominalis,* and of Maulik (1936) in *A. foveicollis.* So far, no author seems to have mentioned the condition of the pygidium in *A. atripennis* and *A. cincta;* the present author, however, finds that the pygidium in these two species do not show any sexual differences as in the case of *A. foveicollis.* Both, Maulik and the present author, have noted that the different species of *Aulacophora* show well marked sexual dimorphism. The other Indian genus included in the sub-family Galerucinae, i.e., *Galerucella,* however, does not show well-marked sexual dimorphism or secondary sexual characters.

The Head :

In the head, the post-clypeus is smooth in *Aulacophora* but is hairy in *G. birmanica;* on the other hand the anti-clypeus is hairy in *Aulacophora,* but is smooth in *G. birmanica,* as shown by Khatib (1946). The labrum in the two genera shows differences in their tormae; in *Aulacophora,* the tormae are in the form of straight rods which are bent in the form of a hook posteriorly, but in *G. birmanica,* they are in the form of simple, curved rods only. The labrum epipharynx is hairy but seems to be devoid of special sensory patches as have been described in *G. birmanica* by Khatib. In *Aulacophora,* the posterior tentorial pits are situated near the anterior ends of the gul and thus the gular sutures, which form the lateral boundaries of the gula, are forward prolongations of the post-occipital sutures, as is the case in several beetles with prognathous head like *Epicanta, Staphylinus,* etc., (Snodgrass, 1935). According to Khatib, in *G. birmanica,* the posterior tentorial pits are situated on either side, near the base of the gula, and thus the post-occipital sutures are not prolonged forward beyond these pits to form the sides of the gula, as is the case in *Aulacophora.* The occipital arch, in *Aulacophora,* is divisible into a median dorsal occiput and a pair of small lateral processes, but in *G. birmanica,* the occipital arch is simple and is devoid of any trace of the lateral processes. The tentorium in *Aulacophora* is extremely rudimentary and in this respect it closely resembles the condition found in *G. birmanica.* In *Aulacophora,* the dorsal arms of the tentorium are absent and the posterior arms are represented by small thickenings only, as in *G. birmanica.*

The mouth parts of *Aulacophora* like those of *Galerucella,* are of the orthopteran (biting and chewing) type. The mandible in *Aulacophora* is provided with six teeth while in *G. birmanica,* the mandible has only five teeth. The third incisor tooth is the largest in both the cases. In *Aulacophora,* there is a well developed molar lobe with a masticatory surface composed of a series of closely packed parallel ridges separated by grooves, but a molar lobe is absent in *G. birmanica.* The prostheca in *Aulacophora* is in the form of a narrow flexible lobe while in *G. birmanica* it is

oval and leaf-like. No sensory spots have been observed on the ventral side of the mandibles in *Aulacophora*, as has been described by Khatib in *Galerucella*.

The maxillae and labium are of the usual coleopteran type and resemble those of *Galerucella*. In the labium, however, the palpigers of *Aulacophora* are more closely approximated mesially than is the case in *G. birmanica*.

In *Aulacophora*, the hypopharynx is provided with a pair of lateral processes or superlinguse, but these are absent in *G. birmanica*. In the latter, the two chitinous hypopharyngeal bars of the hypopharynx are connected with each other by a transverse chitinous rod, but such a connection is wanting in *Aulacophora*.

The Cervicum or Neck Region :

The cervicum, or the flexible intersegmental membrane connecting the head and thorax, shows a number of cervical sclerites in many groups of insects and are best developed in the more primitive groups like Orthoptera, Dermaptera, Isoptera. Odonata, etc. They usually consist of a pair of lateral sclerites, one behind the other on each side, though in some of the least modified forms' paired dorsal and ventral sclerites are also present in addition to the lateral sclerites. The neck sclerites have been indicated in Coleoptera by Crampton (1917, 1926), Martin (1916), Saxena (1951-53), etc., but the neck sclerites are totally wanting in *Aulacophora*. In this respect it resembles the condition found in *G. birmanica*.

The Thorax :

In the prothorax of *Aulacophora*, the pronotum is divisible into three transverse areas as mentioned by Maulik (1936), but such division into transverse areas is not met with in *G. birmanica*. In other respects the prothorax is similar in both the genera.

In the mesothorax of *Aulacophora*, the mesoscutellum is in the form of a median plate and overlies the scutum; it does not divide the latter into left and right halves as has been described by Imms (1934) in his description of the thorax of Coleoptera. In this respect the observations of the present author in *Aulacophora* agrees with those of Khatib in *G. birmanica*. The episternum and epimeron reach upto the coxal cavity as in *G. birmanica*, and do not remain away from it as in some other Coleoptera like *Chrysochus auratus* (Wilson, 1934). The mesosternum resembles that of *G. birmanica* and is divisible into a basisternum and a sternellum (Snodgrass, 1935).

Dhe metathorax of *Aulacophora* is essentially similar to that of *G. birmanica* as described by Khatib (1946) and needs no special mention.

The walking legs of *Aulacophora* are essentially similar to those of the subfamily Galerucinae, including the claws which are bifid. The unguitractor is pyriform and a pair of auxillae are present beneath the base of the claws as is the case in all members of the family Chrysomelidae described by Snodgrass (1935).

The Abdomen :

In *Aulacophora*, as in most of the beetles, the first five tergites are well deve-

loped. The first two sternites show considerable variation in the different members of Coleoptera and are more or less reduced. In some they are small and membranous as in *Habrocerus* (Muir, 1919 a) and *G. birmanica* (Khatib, 1946). In *Aulacophora* however, both the first and second sternites are represented by sclerotised portions; the first sternite is represented by a pair of small laterally situated sclerotised areas, but the corresponding areas of the second sternite are united with the antero-lateral margins of the sternite of the third segment, but a distinct suture is present between them. Thus the sternites of the first and second segments in *Aulacophora* are less reduced than those of *G. birmanica*. The sternites of the 3—6 segments show no special features. In the male *Aulacophora,* however, the seventh sternite shows internally a semi-circular plate arising from its anterior border and a median process arising from it which is inserted on the inner surface of the sternite as mentioned by Maulik (1936); Varma (1953), showed that these structures develop as apodemes for the attachment of muscles. The present author agrees with his views. These structures are absent in *G. birmanica.* Moreover, in *Aulacophora*, the seventh sternite is trilobed posteriorly, but it is simply rounded in *G. birmanica.* In the female of both *Aulacophora* and *G. birmanica,* the seventh sternite is devoid of an internal semi-circular plate and its median process. In female *A. atripennis* and *A. cincta*, the seventh sternite is rounded posteriorly as in the female *G. birmanica,* but in the female of *A. foveicollis,* it is notched behind. The eighth segment is highly modified in all Coleoptera. In many Coleoptera like *Habrocerus* (male), it is typically enclosed by four plates, a short tergite, a somewhat larger sternite and a pair of large pleural plates on which the eighth spiracles are situated. In *Aulacophora*, however, the pleural plates are entirely wanting and so are the eighth spiracles. Tanner (1927) mentioned the presence of the eighth spiracles in the female of all Coleoptera studied by him, but these are absent in the female *Aulacophora,* and in this respect the present observations agree with those of Khatib (1946) in *G. birmanica.*

The eighth tergites of the male and female *Aulacophora* do not show any unusual features, except that in the male, it is very strongly chitinised along its posterior margin and in the female, it is membranous, except along the posterior and lateral margins which are sclerotised. The eighth sternite is well developed and heavily chitinised in the male of some Coleoptera like *Habrocerus* (Muir, 1919a), but in *Aulacophora* it is absent as in *G. birmanica* (Khatib, 1946). In the female, the eighth sternite is well developed as in most Coleoptera, though in *Aulacophora* it is membranous except for the margins; internally a median spiculum arises from it and projects forward into the abdomen for the attachment of muscles, as in *Anthonomous pomorum* (Metcalfe, 1932). In *G. birmanica,* the medium spiculum seems to be absent, as Khatib (1946 and 1946a) has not made any reference to this structure in his accounts.

The ninth segment is also highly modified. In many Coleoptera, like male *Tachyporous* and male *Leistotrophus,* it has four sclerites, a dorsal tergum, a ventral sternum and a pair of pleural plates. In both male as well as in female *Aulacophora*, dis-

tinct pleural plates are absent as in *G. birmanica*. In some male Coleoptera, the ninth tergum is reduced as in *G. birmanica* where it is represented by a pair of exceedingly small chitinised plates connected with each other by a membrane, but in *Aulacophora*, even these are wanting and the ninth tergum is represented by a membranous area only which forms the dorsal wall of the male genital chamber. In the female *Aulacophora*, the ninth tergite is present in the form of a small, membranous plate situated below the eighth tergite; its posterior and lateral margins are, however, well sclerotised. In *G. birmanica*, it is in the form of small, oval plate, the lateral borders of which alone are well chitinised. In some male Coleoptera, the ninth sternite is reduced or absent; in *Aulacophora*, as in *G. birmanica*, it is not recognisable as a distinct structure. In the female Coleoptera also in many instances, the ninth sternite is reduced or absent and is represented by a pair of genital palps only, which are borne on chitinous plates. In female *Aulocophora*, the sternite of the ninth segment is represented by a pair of genital palps which are attached to a small strongly chitinised basal sclerite, which gives off anteriorly a pair of curved rod-like processes or baculi as described in Chrysomelidae by Tanner (1927). In *G. birmanica*, the ninth sternite is represented by a pair of widely separated, unjointed, genital palps borne on chitinous plates and the baculi seem to be absent. Genital palps, no doubt, represent the elongated coxites of the ninth sternum as accepted by several authors like Metcalfe (1932), Pruthi (1924), Tanner (1927), Imms (1934), etc. It is just possible that the median basal sclerite to which the genital palps are attached in *Aulacophora*, represent the remnant of the ninth sternite, as in this animal the genital palps are not attached to a pair of strongly chitinised basal sclerites as in some other Coleoptera, and that the baculi represent the lateral chitinised margins of the ninth sternite which have become greatly prolonged anteriorly. Some authors regard that the insect abdomen consists of ten segments and according to Snodgrass (1935), it is represented by the membranous area round the anus. This seems to be true for *Aulacophora* also.

SUMMARY

The external and internal morphology of *A. foveicollis* Luc., has been described in detail and points of differences with *A. atripennis* and *A. cincta* have been mentioned. Secondary sexual characters are well marked in the three species, and affect the size of the animals, the antenna, the pygidium and the last visible sternite. In *A. atripennis* and *A. cincta*, however, the pygidium shows no differences on account of sex. In the head, the frontal or interantennal area is covered with a thick covering of hairs, but these are absent from the apex. The anteclypeus is also hairy but the postclypeus is smooth. The lower ends of the post-occipital sutures are greatly elongated and their ends are marked by the posterior tentorial pits and thus there is a well-developed gula. Subgenal sutures are absent. The tentorium is rudimentary and a tentorial bridge between the posterior arms is absent.

The antenna has eleven segments. The mandible is provided with an incisor lobe having six teeth, a molar lobe, and a hairy narrow plate like prostheca. The palpigers of the labium are closely approrimated. The

hypopharynx is provided with a pair of superlinguae. The pretarsus bears the unguitractor as well as auxillae besides the two bifid claws.

The prothorax of *Aulacophora* — the pronotum is divided into three transverse areas. In the mesothorax — mesoscutellum is in the form of a median plate overlying the scutum. In metathorax — it *is the larger segment* and typical anticostal and post costal scuto-scutellar suture, convergent sutures, oblique sutures are found as important sutures.

In the abdomen, the first sternite is represented by a pair of small sclerotised areas, the two small pieces of reduced second sternite are suturally united with the third sternite. In the male, the seventh sternite shows specific differences in the three species. Internally, the seventh sternite in all the three species shows a large semicircular plate, with a median process projecting from its posterior side. In the female, an eighth sternite is present, but it seems to be absent in the male. In the female, the ninth tergite is chitinised but it seems to be absent in the male. In the female, there is a pair of small, unjointed, closely approximated genital palps which are grooved mesially. They are attached to a small, median, chitinised plate, which is produced anteriorly into a pair of baculi.

Explanations of Lettering

A C S	—	Antecostal suture
A C T G	—	Acrotergite
A N	—	Antenna
A T	—	Anterior tentorial pit
A N S	—	Antennal suture
A U X	—	Auxillae
A W P 1	—	Anterior wing process of mesothorax
A W P 2	—	Anterior wing process of metathorax
A X	—	Axillary sclerites
B A	—	Basalare
B A C	—	Baculi
B S T	—	Basisternum
C D	—	Cardo
C D'	—	Cardo condyle
C L	—	Claw
C L S	—	Clypeo labral suture
C L P	—	Clypeus
C L P'	—	Anterior clypeus
C X	—	Coxa
C X C	—	Coxal cavity
C X 1 — C X 3	—	Coxa of 1st to 3rd legs
E	—	Eye

E L S	—	Enigmatic longitudinal suture
E M_2 — E M_3	—	Meso and meta epimeron
E U S	—	Eusternal lobe
E U S_1 — E U S_3	—	Pro, meso and metaeusternum
E S T	—	Eustipes
E S_2 — E S_3	—	Meso and metaepisternum
F L	—	Flagellum of antenna
F	—	Frons
F M	—	Foramen magnum
F S	—	Frontal suture
F U	—	Furca
F U P	—	Furcal pit
G	—	Gena
G A	—	Basi galea
G A'	—	Disto galea
G M S	—	Gulomentum suture
G P	—	Genital palp
G U	—	Gula
G U S	—	Gular suture
L	—	Labium
L_1 — L_3	—	Ist, 2nd and 3rd legs
L A	—	Lacinia
L B	—	Labrum
L B A	—	Anterior labrum
L B P	—	Posterior labrum
L G	—	Ligula
L L	—	Lateral lobe
L P	—	Labial palp
M D	—	Mandible
M L	—	Median lobe of 7th sternite of male
M G R	—	Median groove
M N	—	Mentum
M X	—	Maxilla
M X P	—	Maxillary palp
N O	—	Notaulices
O A	—	Occipital arch
O S	—	Occipital suture
O S'	—	Oblique suture
P D	—	Pedicel
P F	—	Palpifer
P G R	—	Palpiger
P M	—	Prementum
P C L	—	Post clypeus

Fig.

P R L	—	Proleg
P L	—	Pleura
P C X	—	Pre coxale
P O C X	—	Post coxale
P T	—	Posterior tentorial pit
P S	—	Pre scutal suture
P O	—	Post occipital
P O S	—	Post occipital suture
P S U	—	Pleural suture
P H R 1, 2, 3	—	Ist to 3rd phragma
P S C L 3	—	Meta proto scutellum
P S C 2, 3	—	Meso and Meta prescutum
P W P_1	—	Post wing process of mesonotum
P N	—	Pronotum
S	—	Seta (SET)
S C	—	Scape
S B A	—	Sub — alare
S C_2, S C_3	—	Meso and Meta scutum
S L	—	Super lingua
S M	—	Sub mentum
S H Y	—	Suspensorium sclerite of hypopharynx
S P	—	Spiracle
S C L_2, S C L_3	—	Meso and Meta scutellum
S S	—	Sternal suture
S P G	—	Spiculum gastrale
S T R 1 — 9	—	Abdominal sternites from 1 to 9
S T R L	—	Sternellum
T_1 — T_5	—	Ist to 5th tarsul of walking leg
T B	—	Tibia
T N	—	Trochantin
T R	—	Trochanter
T P L	—	Ungutractor plate
T G R 1 — 9	—	Terga 1 to 9
T O R	—	Tormae
V	—	Vertex
V S	—	Scuto scutellar or V shaped suture

EXPLANATION OF FIGURES :

Fig. 1. A. *Aulacophora foveicollis* Luc.
Antenna of the male.
B. *Aulacophora foveicollis* Luc.
Antenna of the female

C. *Aulacophora atripennis* Fab.
Antenna of the male.

D. *A. atripennis* Fab.
Antenna of the female

E. *A. cineta*
Antenna of the female.

F. *A. cineta*
Antenna of the male.

Fig. 2. A. *A. foveicollis* Luc. Ventral view of the tip of the male abdomen showing the characters of the seventh sternite.
B. *A. foveicollis* Luc. Ventral view of the tip of the female abdomen.
C. *A. atripennis* Fab. Ventral view of the tip of the male abdomen.
D. *A. atripennis* Fab. Ventral view of the tip of female abdomen.
E. *Aulacophora cincta* Fab. Ventral view of the tip of the male abdomen.
F. *A. cinta* Fab. Ventral view of the tip of the female abdomen.

Fig. 3. A. *Aulacophora foveicollis* Luc. Dorsal view of the head capsule.
B. *Aulacophora foveicollis* Luc. Ventral view of the head capsule.
C. *Aulacophora foveicollis* Luc. Dorsal view of the labrum.
D. *Aulacophora foveicollis* Luc. Ventral view of the mandible.

Fig. 4. A. *Aulacophora foveicollis* Luc. Ventral view of the maxilla.
B. *A. foveicollis* Luc. Ventral view of the labrum.
C. *A. foveicollis* Luc. Dorsal view of the hypopharynx.

Fig. 5. A. *A. foveicollis* Luc. Pronotum of the male (Dorsal view).
B. *A. foveicollis* Luc. Pronotum of the female (Dorsal view).
C. *A. atripennis* Fab. Pronotum of the male (Dorsal view).
D. *A. cincta* Fab. Pronotum of the male (Dorsal view).

Fig. 6. A. *A. foveicollis* Luc. Posterior view of the prothorax showing the arrangement of the sclerites.
B. *A. foveicollis* Luc. Ventral view of the prothorax.

Fig. 7. A. *A. foveicollis* Luc. Lateral view of the prothorax, mesothorax and metathorax showing the arrangement of the sclerites.
B. *A. foveicollis* Luc. Dorsal view of the mesothorax and metathorax showing the arrangement of the sclerites.
C. *A. foveicollis* Luc. Ventral view of the mesothorax and metathorax.
D. *A. foveicollis* Luc. Posterior view of the metafurca isolated from the metathorax.

Fig. 8. A. *A. foveicollis* Luc. First walking leg, to show the parts of a leg.
B. *A. foveicollis* Luc. Tarsus of the first leg to show the parts in detail.

Fig. 9. Lateral view of the abdomen of *Aulacophora foveicollis* to show the tergites, sternites and the position of the abdominal spiracles.

Fig. 10. A. *A. foveicollis* Luc. Eighth tergite of the male (Dorsal view.)
B. *A. foveicollis* Luc. Eighth & ninth tergites of the female (Dorsal view).
C. *A. foveicollis* Luc. Eighth sternite of the female showing the spiculum. (ventral view).
D. *A. foveicollis* Luc. Genital palp and the baculi of the female.

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